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LANDSCAPE OF NORTHERN GREENLAND

William E. Davies

March 1972

PREPARED FOR
ADVANCED RESEARCH PROJECTS AGENCY
ARPA ORDER 1615
BY
MILITARY GEOLOGY BRANCH
U.S. GEOLOGICAL SURVEY
UNDER CONTRACT WITH
CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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PREFACE

This report was prepared by William E. Davies, Geologist, Military Geology Branch, U.S. Geological Survey, for the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL Order 70-20). The work is part of the Arctic Surface Effect Vehicle program funded by the Advanced Research Projects Agency (ARPA Order 1615).

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The terrain, geomorphology, physiography and general environmental setting of Northern Greenland are the subject of this report. There are no clear cut regional designations for Greenland; therefore for the purposes of this report Northern Greenland has been arbitrarily set as the area north of 79° on both the east and west coasts. The general topography, geology, vegetation, climate and permafrost conditions are discussed to provide an indication of the environmental setting. A new physiographic classification for Northern Greenland is proposed. Three basic concepts have been followed in establishing the physiographic divisions: (1) the divisions have been established to be applicable to all of Greenland; (2) they have been correlated as far as practicable with those already established in Canada; and (3) to be systematic, they follow the general criteria and scheme established by Fenneman and others for the United States. A terrain classification of this area is also presented with an emphasis toward cross-country operation of air cushion vehicles. This type of approach is very useful for operational analyis of vehicles of this type in this area. The land area has been broken down into seven categories with varying degrees of suitability for air cushion vehicle operations. Under each category a number of specific conditions are discussed such as: landform; terrain, including relief snd slope relief features, their height, spacing and orientation; stream frequency; vegetation; soil types; and winter conditions. Additional information is provided on relief and conditions associated with summer and winter shore ice. The detailed geomorphology of five selected areas at scales of 1:100,000 or larger was mapped. These areas were selected to provide additional detail on Northern Greenland since they include most of the landforms and physiographic types found in this region.

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CONTENTS

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A terrain classification of this area is also presented with an emphasis toward cross-country operation of air cushion vehicles. This type of approach is very useful for operational analysis of vehicles of this type in this area. The land area has been broken down into seven categories with varying degrees of suitability for air cushion vehicle operations. Under each category a number of specific conditions are discussed such as: landform;terrain, including relief and slope relief features, their height, spacing and orientation; stream frequency; vegetation; soil types; and winter conditions. Additional information is provided on relief and conditions associated with summer and winter shore ice.

The detailed geomorphology of five selected areas at scales of 1:100,000 or larger was mapped. These areas were selected to provide additional detail on Northern Greenland since they include most of the landforms and physiographic types found in this region.

INTRODUCTION

There are no clear cut regional designations for Greenland. The term northern Greenland has been used in various ways to cover part or all of the area north of Kap York on the west coast and north of Danmark Havn on the east coast. In this description of terrain the extent of northern Greenland has been arbitrarily set as the area north of 79° on both the east and west coasts. This is a convenient breaking point because on the east coast 79° is at the southern end of the extensive ice-free land area and on the west coast it lies along the broad Humboldt Gletscher which disrupts the continuity of ice-free land.

Topography - The gross features of topography in northern Greenland are relatively simple. Along both the north coast and east coast are belts of alpine mountains inland from which is an area of plateaus. The upland surfaces of the plateaus are concordant even though they have been dissected into a tableland of large mesa-like forms. In addition both the alpine mountains and the plateaus have been separated into segments by the many large fjords that extend from the sea to the ice sheet that covers the interior of Greenland. In the northeastern part of the area is a narrow zone of plateaus on the seaward side of the alpine mountains.

Geology - The gross features of the geology are also relatively simple and are reflected directly in the topography (fig. 1). The interior part of Greenland that is occupied by the ice sheet is a shield of Precambrian metamorphic and igneous rocks. Bordering the shield is a zone of gently northward dipping sedimentary rocks ranging from probably Cambrian through Silurian in age. The oldest sedimentary rocks in this sequence are possibly Proterozoic in age and consist of sandstone, shale, and dolomite that have not been deformed nor metamorphosed. However, this part of the sequence includes numerous basic intrusions in the form of sills and dikes. The clearly Cambrian rocks are dominantly carbonates with some sandstone and minor amounts of shale. The carbonate rocks are also dominant in the Ordovician and Silurian section (fig. 2). Reef limestones form much of the lower and middle Silurian in the western part of the area (Washington to Wulff Lands) and the upper Silurian contains shale and sandstone throughout the area (Dawes, 1971). The total thickness of sedimentary rocks in the west part of the area is about 6,500 feet and about 10,000 feet in the east.

Orogenic movements at the close of the Silurian terminated sedimentation in the inner plateau area. The orogeny also produced folding and faulting accompanied by metamorphism in the coastal fringe of the area (fig. 3). Along the northern coast the metamorphism occurred in a broad zone lying generally north of Frederick E. Hyde and J. P. Koch Fjords (fig. 4). The zone of metamorphic rocks apparently underwent additional metamorphism in Cretaceous-Tertiary time (Laramide). On the north side of the folded belt, between DeLong Fjord and Kap Christian IV, is an east-west zone of lavas and tuffs up to 5,000 feet thick that have undergone no regional metamorphism. They have a gentle dip to the south and in places are gently folded. The exact age of these extrusions is not known but they post date the main Paleozoic diastrophism and some evidence indicates they are of Cretaceous-Tertiary age (Dawes, 1971).

On the east side of Greenland orogenic movements occurred in late Precambrian time and the sedimentary rocks were gently folded but not metamorphosed. The main orogenic movements along the east coast occurred in the late Silurian and early Devonian resulting in a marginal thrust belt forming a series of westward displaced nappes. The easternmost

nappes were intensely folded and metamorphosed while the nappes to the west were successively less folded and metamorphosed. After this disturbance the western flank of the Paleozoic basin remained positive and a part of the continent. The eastern side along the sea, however, subsided and was covered by Permian marine and continental deposits. The shallow sea along the continental shelf persisted into the Tertiary and sediments were deposited in fluctuating marine and continental environments. Uplift in the Tertiary and Quaternary raised the sediments, which are dominantly sandstones, and they now stand as low coastal plateaus (Haller, 1970). Some orogenic movements in the early Mesozoic produced a narrow belt of tilted blocks of Permian sandstones north of Independence Fjord.

The rocks of most of northern Greenland have apparently been exposed to erosion since the middle Paleozoic yet much of the upland is intact and dissection is only moderate. The remnants of Silurian rocks throughout much of the area extending westward from north of Independence Fjord indicate that this zone has suffered very little erosion. However, the rocks in this area are considerably more dissected than those to the south of Independence Fjord where most of the post-Cambrian rocks have been removed. In examining the geologic map it is apparent that the area surrounding the Greenland shield has been positive and undergone progressive uplift and erosion while the area north of Independence Fjord to Frederick E. Hyde Fjord has been relatively static. The concordant plateau tops throughout the area south of the fringe along the folded mountains indicate that some type of erosional equilibrium approaching peneplanation occurred subsequent to the uplift at the end of the Silurian and previous to the Pleistocene (fig. 5). Considering 1) the extent of concordant, undissected upland, 2) the concordant surfaces extending over both pre-Cretaceous and Cretaceous rocks, and 3) the dissection of the Silurian rocks along the fringe of the folded mountains in Peary Land, it is probable that the concordant surface of the plateau area reflects erosion to base level in middle to late Tertiary. An older erosion level is also indicated by the concordant surface of the folded but unmetamorphosed rocks along the south side of Frederick E. Hyde Fjord. This surface, sloping gently to the southeast, is concordant with the summits underlain by Silurian rocks on the south flank of the mountains and is probably the same surface on which Pennsylvanian - Permian rocks were deposited in the eastern part of the area.

Glaciation - During the Pleistocene northern Greenland was glaciated at least three times. In the oldest recognizable glaciation, possibly equivalent to the Mindel (Kansan), the ice reached its greatest extent. The lobes and valley glaciers from the Greenland ice sheet and from ice caps in Peary Land and Johannes Jensen Land covered all of the land area except for a small refugium in eastern Peary Land. The second recognizable glaciation, possibly Riss (Illinoian), was less extensive and the main Greenland ice sheet expanded only a little beyond its present front. However, glaciers extended down the major fjords terminating in the lower

parts of the fjords and overrunning the lowlands along the fjord coasts. Much of the upland was ice-free and the interior parts of the lowlands escaped glaciation. The withdrawal of the ice after this glaciation was considerable and the front of the Greenland ice sheet was up to 20 miles further inland than it is now. The third and latest glaciation (Würm-Wisconsin) was the least extensive of the three and was primarily an extension of glaciers down fjords. The ice sheet itself extended only about 7 miles at the most beyond its present position and the glacier tongues overrode very little of the lowland. The decline in intensity of successive glaciation is probably a reflection of progressive increase in aridity in northern Greenland throughout the Pleistocene.

The effect of glaciers on the topography is much less than would be expected in an area adjacent to an ice sheet. Most of the upland remains intact and shows little alteration from glaciation. The valleys have been moderately enlarged and modified by alluviation. Morainal systems are not well developed and areas of glacial deposition are primarily along short segments of coastal flats and along large valleys. Glacial-fluvial features are prevalent in lowlands along with older morainal deposits greatly modified by erosion and redeposition. Sculpturing by glaciation is extensive in the mountainous area and much of the coastal mountain zones are occupied at present by large ice fields and valley glaciers.

Permafrost - Permanently frozen ground is continuous throughout all of northern Greenland. Based on observations at a deep well at Thule, the permafrost extends to a depth of over 2,000 feet. In most years there is only a single freeze and a single thaw period. The active zone above permafrost generally extends to a depth of 18 to 24 inches. In general, because of the aridity of the area, moisture is low in this zone throughout the year and variation in ground ice content is small during the freeze-thaw cycles. Polygons are extensive in thick morainal deposits on the lowlands and on river and marine terraces. The polygons are the depressed-edge type, up to 500 feet on a side. Most of the upland is free of polygons but stone nets and rings are common. A unique feature in the vicinity of Brønlund Fjord is the raised-edge polygon developed in bedrock (Davies, 1961c). Throughout the entire area desiccation polygons are common (fig. 6). They are 4 to 6 sided and are up to 10 inches on a side with gently domed centers.

Climate - Northern Greenland has two distinctive climatic zones. The coastal fringe in the west from Hall Land to Nares Land and from Bliss Bugt to Holm Land, including the lower parts of Danmark and Independence Fjords, is subhumid. The climate inland from these areas is arid. The temperature is similar in the two zones with annual mean daily temperatures of 1° to 4°F, absolute maxima of 53° to 64°F, and absolute minima of -45° to -60°F. There are great contrasts in precipitation between the zones. In the arid area annual percipitation is on the order of 2.3 to 5 inches per year with precipitation occurring on 68 days. In the

subhumid area the precipitation is up to 15 inches and occurrence is 175 to 196 days per year. Snowfall is as much as 65 inches per year in the subhumid area but less than 24 inches in the arid area. Clear days (less than 3/10 cloud cover) are about the same order in both zones, averaging 130 to 140 days per year. Cloudy days (8/10 or more cover) average about 190 days in the subhumid region and 120 days in the arid area. Gales are prevalent on 100 to 105 days per year on the average in both the arid and subhumid zones in the east but only about 30 days in the west.

Vegetation - Plant life is composed of low flowering plants, sedges, grass, and ground hugging, dwarf willow. It is confined to the areas of wet soils along river bottom lands, and in sags and swales on terraces and uplands. Most patches of vegetation cover only a few square feet and are separated by broad barren areas. The most lush vegetation, generally grass in wet lowland areas, covers less than a 100,000 square feet in the largest stands. Peat, muskeg and bogs are absent from this part of Greenland.

PHYSIOGRAPHY OF NORTHERN GREENLAND

Physiographic studies in northern Greenland have been concerned mainly with description of specific landforms with little or no consideration for systematic correlation and classification. Lauge Koch (1928b) prepared the only extensive coverage of the area, primarily a description of significant but isolated areas and features. Stearns' (1965) study of cold regions physiography touched upon the systematic relationships within the whole of the Arctic but did not cover subordinate areas in detail.

Geomorphic descriptions of portions of Inglefield Land (Nichols, 1969; Bendix-Almgreen, Fristrup, and Nichols, 1967), Washington Land (Malaurie, 1968), and Peary Land (Troelson, 1952; Koch, 1923; Victor, 1955; Davies, 1961a) have been published. None of these descriptive studies attempted to fit the geomorphology into a systematic physiographic framework.

The present study is based on field work in northern Greenland in 1953, 1956, 1958, and 1960 augmented by a study of vertical photography of the Danish Geodætisk Institut and trimetrogon aerial photography of the U. S. Air Force. Without the aerial photography it would not have been possible to define and correlate the various geomorphic features that can be systematically grouped to form the various physiographic units.

Basis for Classification

In establishing the physiographic divisions of northern Greenland three basic concepts have been followed: first, the divisions have been established so as to be applicable to all of Greenland; second, they have been correlated as far as practicable with those already established in Canada; and third, to be systematic, they follow the general criteria and scheme established by Fenneman and others (1946) for the United States. In this scheme the major physiographic features which parallel major tectonic systems are classified into divisions and each division successively divided into provinces, and sections. Because of the relatively large scale of the physiographic map of northern Greenland and the numerous important smaller variations, numerous subsections have been described. The numbering system adopted for this study assigns a block of 10 numbers to each province and a single progressive number to each section within the province. Subsections are designated by lettered suffixes. This permits extensions to other parts of Greenland without disruption or duplication within the system.

Although northern Greenland shows evidence of at least three distinct cycles of glaciation, the topography essentially is a direct

reflection of the bedrock. Glaciers have smoothed some of the landforms and have buried others, but in general the topography is little modified. The extreme aridity of the area, which apparently has persisted through the Pleistocene to the present, has been of great significance for it curtailed glacial action, has greatly limited stream erosion, and has prevented plant growth.

The criteria in establishing physiographic units are based primarily on landforms with additional consideration given to the history of development of the form and its relation to great tectonic features. If only topography were considered, the east Greenland alps would be classified in a unit with the alpine mountains in northern Greenland giving rise to a misleading correlation in terms of geologic history. Similarly, the plateaus along the east coast would be grouped with the inland plateaus giving rise to another erroneous correlation.

Physiographic Divisions

Two major physiographic systems extend into Greenland - the Innuitian Highland and the East Greenland Caledonides (plate 1). The former is related to the tectonics of the North American continent while the latter is a possible reflection of European tectonics. The Innuitian System forms a mountainous belt along the northern part of the Canadian Arctic Islands extending east from M'Clure Strait to Ellesmere Island and into Greenland. In Canada this system is the same as that designated Innuitian Region by Bostock (1970).

The East Greenland Caledonides are similar in many respects to the Innuitian Highland and extend along the east coast of Greenland from Kangerdlugssuaq northward. Although no previous physiographic correlation has been made, Haller (1970) has correlated the tectonics of this fold belt with the circum-Scandic domain.

In Greenland the two systems are separated by a shield of Precambrian basement rocks that correlates with the Canadian Shield with respect to geologic features. However, from a physiographic viewpoint such a correlation is limited because most of the shield area is buried beneath the ice sheet that covers much of Greenland.

In correlating physiographic units, the magnitude of subdivisions in Greenland and Canada differ. The Canadian subdivisions are those of a vast continent and do not strictly follow the scheme used in Greenland. In Greenland, the system, which is tied to major tectonic feature, is the primary unit of classification. In Canada Bostock (op. cit.) has divided the physiography into two units - the Shield and the Borderlands which rank above the regions (systems). In Greenland such a classification would place most of Greenland in the Shield with the Borderlands

composed of the Innuitian Highland and the East Coast Caledonides.

The plateau lying between the mountain belts and the shield area in northern Greenland presents a problem in classification. In East Greenland, the Caledonides have been folded and the nappes thrust from the east making the plateau area to the west a true foreland (Haller, 1970). In the north, however, recent work (Dawes, 1971) has shown that the mountain forming movements were from the south, making the complementary part of the plateau a hinterland. Since the plateau is a continuous feature tied equally to the two mountain systems, it would be awkward and inconsistent to arbitrarily designate one part a foreland and the other a hinterland. Because the plateau has the geomorphic features of a foreland it was classified in this study as such, recognizing that this violates certain of the tectonics established for northern Greenland. It was also necessary to separate the plateau at an arbitrary point to properly assign parts of it to the major physiographic systems to which it is complementary. The line of separation was made along Hagen Fjord which is a structural high separating two major basins.

INNUITIAN HIGHLAND

The alpine mountains and plateaus across northern Greenland are a major physiographic entity. Although the mountains and plateaus are the dominant geomorphic elements of the system, there are extensive areas of lowlands, composed of plains, coastal strands, and piedmonts included in the system.

North Greenland mountains province

This province is composed of the alpine mountains and piedmonts lying along the north coast of Greenland. The Arctic strand at the foot of the mountains is also included as it is a coastal pediment cut into the mountains. The province is subdivided into three sections and six subsections.

NANSEN-JENSEN ALPS (Section 1) - The high alpine mountains lying generally north of Frederick E. Hyde and J. P. Koch Fjords form a distinct physiographic unit (fig. 4). Along Frederick E. Hyde Fjord, the mountains have been highly modified by erosion resulting in an area of irregular, subdued ridges and piedmonts.

1a. Roosevelt Range

Topography: Alpine mountains; altitude 2,600 to about 6,200 feet; relief up to 4,000 feet; slopes 30° to vertical on ridges and spurs; cliffs as high as 800 feet extend along major fjords.

Drainage: Few lakes or rivers; most valleys occupied by glaciers; 2 large lakes cover 20 sq. miles; 2 small lakes cover 1 sq. mile; streams up to 10 miles long but generally less than 5 miles in length; drainage pattern of short streams, parallel; of longer streams, dendritic.

Ice caps and glaciers: Large mountain icefields; numerous nunataks; large valley glaciers drain icefields; total area of icefields and glaciers 1,200 sq. miles.

Soil: Mainly rubble fields and bedrock.

Permafrost: Continuous; no surface features.

Area of subsection: 3,670 sq. miles.

Bedrock: Proterozoic to Silurian metamorphic rocks, mainly quartzite, schist and slate, some marble; post-Silurian volcanics, gently dipping, not metamorphosed on Arctic coast between DeLong Fjord and Kap Morris Jesup.

References: Amdrup, 1913; Borup, 1911; Ellitsgaard-Rasmussen, 1955; Elvin, 1934; Fielden and DeRance, 1878; Fränkl, 1954b, 1955a, 1955c; Greely, 1886; 1888; Holmen, 1957; Jeffries, 1977a, 1877b; Knuth, 1957; Koch, 1917, 1923, 1926; 1928a, 1935, 1939, 1940; MacMillan, 1934; Nares, 1878; Peary, 1903a, 1907; Rasmussen, 1919, 1921, 1928; Røen, 1965.

1b. Frigg Fjord Eroded ranges

Topography: Low, irregular, narrow ridges; altitude sea level to 3,500 feet; relief up to 1,500 feet; steep side slopes; cut by numerous glacial marginal channels.

Drainage: Columbus Sø, only large lake; trunk streams spaced, 2½ to 5 miles; tributaries, 1 to 3 miles; drainage pattern, dendritic, two trunk streams braided.

Ice caps and glaciers: Three small valley glaciers, 4 sq. miles.

Soil: Rubble fields in upland; cobbly, sandy silt and bedrock along marginal channels; sand along braided stream channels.

Permafrost: Continuous; no surface features.

Area of subsection: 430 sq. miles.

Bedrock: Folded dolomite and sandstone, Proterozoic to Silurian age.

References: Fränkl, 1954b, 1955a, 1955c; Koch, 1935, 1939.

1c. Hundeskræeten piedmont

Topography: Rolling lowland with several northwest trending low ridges; altitude 300 to 2,000 feet; relief up to 1,000 feet; cliffs, up to 1,000 feet high along Frederick E. Hyde Fjord.

Drainage: Small lake less than 1/2 sq. mile; valleys of major streams, up to 300 feet wide with steep valley walls; streams less than 10 miles long, spaced 3/4 to 2 miles; drainage pattern, parallel with local trellis drainage.

Ice caps and glaciers: None.

Soil: Extensive rubble fields with large angular boulders; central area, cobbly, silty sand with boulders.

Permafrost: Continuous; no surface features.

Area of subsection: 100 sq. miles.

Bedrock: Folded sandstone, some dolomite, Proterozoic to Silurian age.

References: Amdrup, 1913; Koch, 1917.

NYEBOE - PEARY LAND MOUNTAINS (Section 2) - To the south of the alpine mountains is a zone of rounded, simply folded mountains of low to moderate elevation. Included with these mountains are areas of foothills and piedmont having rounded, rolling forms similar to the mountains.

2a. Foreland ranges

Topography: Rounded ridges and smooth dome-shaped uplands; altitude, 1,300 to 3,700 feet west of Victoria Fjord, 2,000 to 5,300 feet east of Victoria Fjord; relief, up to 5,000 feet, but 1,300 to 2,000 feet average.

Drainage: Most streams less than 9 miles long, spaced 3/4 to 5 miles in irregular pattern; large trunk stream in Wulff Land flows across ridges in braided channels.

Ice caps and glaciers: 35 ice caps, ranging from 2 sq. miles to 6,100 sq. miles; total area ice covered, 1,410 sq. miles.

Soil: Upland, bedrock and rubble; flanks, stony, silty sand and talus.

Permafrost: Continuous; no surface features.

Area of subsection: 5,170 sq. miles.

Bedrock: Proterozoic to Silurian rocks, open folds, steep dips.

References: Davies and Krinsley, 1961; Davis, 1876; Elvin, 1934; Fielden and DeRance, 1878; Greely, 1886, 1888; Holmen, 1957; Jeffries, 1877b; Knuth, 1951; Koch, 1917, 1926, 1927, 1928a, 1935, 1939, 1940; Nares, 1878; Rasmussen, 1919, 1921, 1928.

2b. Repulse - Bryant piedmont

Topography: Rolling lowland, few rounded dome-shaped hills; altitude, generally 650 to 1,300 feet, with hills up to 2,000 feet; relief, 75 to 650 feet; 5 levels of marine terraces along coast between Hand Bust and Saint George Fjord.

Drainage: One lake, 3 sq. miles; streams less than 10 miles long; spaced 3/4 to 3 miles; parallel pattern.

Ice caps and glaciers: None

Soil: Mainly bedrock; stony silty till and moraine along coast and piedmont inner edge; beaches and marine terraces, cobbly sand.

Permafrost: Continuous; no surface features.

Area of subsection: 145 sq. miles.

Bedrock: Proterozoic to Silurian sandstone and dolomite; open folds with steep dips.

References: Elvin, 1934; Koch, 1928a; Rasmussen, 1928.

2c. Nyeboe-Wulff foothills

Topography: Rolling upland, slopes upward from plateau northwestward to mountains; altitude 1,000 to 3,600 feet; relief, 650 to 2,000 feet; steep slopes and cliffs along St. George Fjord.

Drainage: No lakes; streams less than 5 miles long; spaced 1 to 3 miles in irregular pattern.

Ice caps and glaciers: Two small ice caps; total area 18 sq. miles.

Soil: Upland areas, rubble; elsewhere stony sandy silt.

Permafrost: Continuous; no surface features.

Area of subsection: 234 sq. miles.

Bedrock: Cambrian to Silurian dolomite, some sandstone, open folds, moderate to steep dips.

References: None

ARCTIC STRAND (Section 3) - The Arctic strand is a prominent feature of northern Greenland extending from Independence Fjord to Kap Morris Jesup (fig. 7). It is distinguished from other strands near the mouth of Independence Fjord and along the northeast coast in that it is a lowland cut into bedrock with only a small amount of sediment lying on it. This section is not subdivided.

Topography: Gently sloping plain; short stretches of marine terraces, as many as 14 strand lines rising to 325 feet; altitude, sea level to 650 feet; relief, 6 to 35 feet mainly along terrace fronts.

Drainage: Numerous small lakes cut off by storm ridges and terraces near sea level, occupy 4 sq. miles; streams up to 6 miles long and spaced 3/4 to 4 miles in irregular pattern except from Frederick E. Hyde Fjord to Bliss Bugt where parallel streams are spaced 3/4 to 1½ miles.

Ice caps and glaciers: None.

Soil: Bedrock and angular cobbles along mountain base; marine terraces, cobbly sand.

Permafrost: Continuous; on marine terraces shallow, depressed edge, rectangular polygons, up to 160 feet on a side.

Area of subsection: 450 sq. miles.

Bedrock: Proterozoic to Silurian dolomite and sandstone, tightly folded, steep dips.

References: Amdrup, 1913; Borup, 1911; Davies and Krinsley, 1961; Frankl, 1954b, 1955, 1955c; Holmen, 1957; Knuth, 1951; Koch, 1917, 1923, 1926, 1927, 1928a, 1935, 1940; Laursen, 1954; MacMillan, 1934; Peary, 1903a, 1903b, 1907; Raven, 1965; Troelson, 1952.

North Greenland Foreland plateaus and plains province

South of the mountainous belt of northern Greenland is a broad zone of high plateaus and plains. The plateaus are cut into tablelands by numerous large interconnected valleys. The plains are lowlands eroded from the plateaus and are generally of small extent surrounded by remnants of the upland. Six sections, based mainly on the distribution of lowlands, are recognized in this province.

HALL-NARES TROUGH (Section 11) - A large, complex lowland lies on the south side of the mountainous belt from Hall Land northeast to Nares Land. In its western part are large plains grading into surrounding plateaus.

To the east the lowlands are less extensive and the boundaries between the plains and plateaus are abrupt. The landforms within the trough as well as the trough itself are directly related to the Silurian reef bioherm complex. The plains are on shale on the foreside of the reef, the plateaus in dolomite on the back side and offshore of the reef, and the mountainous plateau ridge of the Hauge Mountains on the reef proper.

11a. Polaris plain

Topography: Undulating plain crossed by low, rounded, morainal ridges; altitude sea level to 550 feet; relief, 3 to 20 feet except along major rivers where relief as much as 65 feet (fig. 8).

Drainage: Two small lakes covering an area 18 sq. miles; streams spaced 1 to 3 miles in an irregular pattern.

Ice caps and glaciers: None.

Soil: Mainly cobbly, sandy silt except for local areas of up to 1/5 sq. mile clayey silt, and along major rivers, larger areas of cobbly stony sand.

Permafrost: Continuous; shallow, depressed-edge, five-sided rectangular polygons in clayey silt, as much as 650 feet per side; desiccated six-sided polygonal cracks in cobbly, sandy silt up to a foot per side.

Area of subsection: 250 sq. miles.

References: Bessels, 1879; Davies, 1961b; Davies, Needleman, Klick, 1959; Davis, 1876; Elvin, 1934; Greely, 1886, 1888; Jeffries, 1877a, 1877b; Koch, 1926, 1927, 1928a; Needleman, Klick, Molineux, 1961; Rasmussen, 1919, 1921.

11b. Hall-Victoria plateaus

Topography: Low, rolling, dissected plateaus; altitude 160 to 2,400 feet; relief, 100 to 200 feet; cliffs locally along major fjords.

Drainage: Wide valleys with gently sloping walls; streams spaced 1 to 6 miles in irregular pattern.

Ice caps and glaciers: 1,870 sq. miles of 33 ice caps, ranging in size from 1 to 550 sq. miles.

Soil: Stony silty sand and rubble fields of platy limestone on upland; talus slopes, locally, on valley flanks and along fjords.

Permafrost: Continuous; no surface expression.

Area of subsection: 2,260 sq. miles.

Bedrock: Ordovician - Silurian platy dolomite dipping to northwest; several open folds with axes trending northeast.

References: Bessels, 1879; Davies, Needleman, and Klick, 1959; Davis 1876; Elvin, 1934; Greely, 1886; Jeffries, 1877b; Koch, 1926, 1927, 1928a; Rasmussen, 1919, 1921.

11c. Hauge Mountains

Topography: Rounded, dome-shaped dissected plateau forming a ridge across southern Hall Land and extending into Nyeboe Land, includes highly dissected rounded plateau lying south of "ridge" area; altitude, 2,300 to 3,200 feet on domes along ridges, 1,300 to 2,600 feet on highly dissected plateau; relief, 30 to 250 feet (fig. 9).

Drainage: Three small lakes, total area $3\frac{1}{2}$ sq. miles; three major streams in alluvial valleys cross area; tributaries up to 10 miles long, spaced 1 to 5 miles in poorly developed dendritic pattern.

Ice caps and glaciers: Four small ice caps and valley glaciers, total area of 20 sq. miles.

Soil: Stony, sandy silt, numerous limestone platy fragments; rubble fields locally on summits.

Permafrost: Continuous; no surface features except irregular polygons up to 200 feet per side with depressed edges occurring in till on upland of western Hall Land.

Area of subsection: 360 sq. miles.

References: Bessels, 1879; Davies, Needleman, and Klick, 1959; Davis, 1876; Greely, 1888; Koch, 1926, 1928a; Rasmussen, 1921.

11d - Polaris highlands

Topography: Small area of steep-sided, highly dissected plateau surrounded by rolling plateau; altitude, 650-1,300 feet; relief, 300 feet, except along Newman Bugt, up to 1,300 feet.

Drainage: No lakes; streams spaced 3 to 5 miles; area crossed by short headwater tributary of a larger dendritic pattern.

Ice caps and glaciers: None

Soil: Shallow, stony, silty sand; rubble fields; extensive bedrock.

Permafrost: Continuous, no surface features.

Area of subsection: 36 sq. miles

References: None

PEARY LAND STEPPED PLATEAU (Section 12) - A small area in northern Peary Land exhibits a unique landform not found elsewhere in northern Greenland. The flat-lying Silurian strata, formed of alternating strong sandstone and weak shale beds, have been sculptured into rounded, symmetrical hills with successive low ledges along the face of the hills (fig. 10).

Topography: Dissected plateau cut into rounded dome-like circular hills; altitude, 1,000 to 4,100 feet; relief, 300 to 1,300 feet, up to 4,000 feet along major valleys and fjords; hills are encircled by successive scarps, 10 to 70 feet high.

Drainage: Five glacial dammed lakes occupy total area 18 sq. miles; trunk streams 9 to 15 miles long; tributaries spaced 2 to 6 miles; poorly developed dendritic pattern.

Ice caps and glaciers: Fifteen ice caps cover 900 sq. miles; ice caps around Nordkronen and Hans Tausen Iskappe cover 144 sq. miles each.

Soil: Mainly rubble; small areas of stony silty sand adjacent to ice caps and on summits formerly occupied by ice caps.

Permafrost: Continuous; no surface features.

Area of subsection: 2,600 sq. miles.

Bedrock: Silurian sandstone, shale, and some limestone; gentle dip to north.

References: Høy, 1970; Koch, 1935, 1939, 1940.

INDEPENDENCE LOWLANDS (Section 13) - The area along much of the north side and the lower part of the south side of Independence Fjord consists of a lowland formed by raised marine beaches and delta terraces. These grade into low plains that have undergone some alteration by glaciation.

13a. Mellville low plateau

Topography: Dissected low plateau; flat upland, little dissection between streams; altitude 1,000 to 2,800 feet; relief, 650 to 1,000 feet.

Drainage: No lakes; streams spaced 1 to 3 miles; modified trellis drainage pattern, trunk streams parallel, tributaries branch in rectangular pattern.

Ice caps and glaciers: None

Soil: Shallow, stony, silty sand; local rubble fields, slabs of limestone.

Permafrost: Continuous; no surface features.

Area of subsection: 500 sq. miles.

Bedrock: Ordovician limestone and some shale; gentle dip to north.

References: Holmen, 1957; Høy, 1970; Knuth, 1951; Koch, 1926, 1927, 1928a, 1935; Troelsen, 1949, 1952.

13b. Vitskøl plain

Topography: Dissected plain; flat interstream areas little dissected; altitude, 650 to 1,200 feet; relief, 30 to 500 feet.

Drainage: No lakes; parallel trunk streams spaced 3 miles with tributaries at right angles on northwest side only; tributaries spaced 1 to 3 miles; sub-trellis drainage pattern.

Ice caps and glaciers: None.

Soil: Shallow, stony, silty sand; extensive bedrock except along southern and eastern edges where thick morainal deposits of cobbly sandy silt occur.

Permafrost: Continuous; no surface features.

Area of subsection: 250 sq. miles.

Bedrock: Silurian limestone and sandstone; gentle dip to northeast.

References: Koch, 1928a.

13c. Fjord strands

Topography: Plains with morainal ridges and kames (fig. 11); altitude, sea level to 525 feet; relief, 10 to 325 feet; along coastal fringe, narrow raised marine terrace, includes raised beaches and lagoon in vicinity of Kap Harald Moltke.

Drainage: No lakes; streams spaced 1/2 to 1 mile in irregular pattern.

Ice caps and glaciers: None.

Soil: Thick deposits of cobbly, sandy silt and gray clayey silt; buff colored silt in raised lagoon.

Permafrost: Continuous; no surface features.

Area of subsection: 200 sq. miles.

Bedrock: Silurian limestone and sandstone; gentle dip to northeast.

References: Davies, 1961b, 1961c; Davies and Krinsley, 1961; Holmen, 1957; Høy, 1970; Knuth, 1951; Koch, 1926, 1927, 1928a, 1935; Laursen, 1954; Rasmussen, 1957; Rodahl, 1948; Stoertz and Needleman, 1957; Troelson, 1949, 1952.

WASHINGTON-CHRISTENSEN TABLELAND (Section 14) - The southern part of the North Greenland Foreland plateaus and plains province is almost entirely a high plateau (fig. 4). It has been dissected into a series of large mesa-like tablelands separated by interconnecting large, flat-floored glaciated valleys (figs. 4, 11, 12).

Topography: Concordant, flat-topped plateaus cut into large mesa-like blocks 4 to 25 miles long; blocks generally bounded by high scarps with steep talus slopes; altitude, 1,300 to 4,700 feet; relief, 300 to 2,600 feet.

Drainage: 181 lakes encompassing 800 sq. miles, largest lake, Midsommersø, 36 sq. miles; streams spaced 1 to 3 miles; poorly developed dendritic drainage pattern west of 40°W. longitude, disarranged by glaciation; trellis pattern in Walcott, Heilprin, J. C. Christensen Lands and adjacent areas.

Ice caps and glaciers: 120 ice caps covering 3,500 sq. miles; largest one, Hans Tausen, covers 930 sq. miles.

Soil: Near ice caps, extensive stony, sandy silt; elsewhere on uplands rubble and block fields; on steep sides of plateau blocks, talus; within 6 miles of Greenland ice sheet, large area of cobbly, silt till.

Permafrost: In till areas, extensive depressed-edge polygons up to 500 feet per side.

Area of subsection: 14,000 sq. miles.

Bedrock: Proterozoic to Ordovician quartzite, sandstone, shale, and dolomite; gentle dip to north.

References: Astrup, 1898; Bessels, 1879; Davies, 1961c; Davies and Krinsley, 1961; Elvin, 1934; Freuchen, 1915; Holmen, 1957; Høy, 1970;

Jeffries, 1877b; Knuth, 1951; Koch, 1926, 1927, 1928a, 1935, 1939, 1940; Laursen, 1954; Peary, 1898; Rasmussen, 1915, 1919, 1957; Rodahl, 1948; Troelsen, 1949, 1952; U. S. Army, Transportation Board, 1960.

EGEDE-TROLLE PLATEAU (Section 15) - This section is similar to the Washington-Christensen tableland but is separated from it by the lowlands on the north side of Independence Fjord.

Topography: Similar to Washington-Christensen tableland; altitude to 3,400 feet, relief to 1,300 feet.

Drainage: Similar to Washington-Christensen tableland; 1 lake encompasses 2 sq. miles.

Icecaps and glaciers: four ice caps encompassing 35 sq. miles.

Soil: Stony, sandy silt; steep sides of plateau, blocks and talus.

Permafrost: Continuous; no surface features.

Area of subsection: 360 sq. miles.

Bedrock: Isolated block of Ordovician limestones and shale; beds horizontal.

References: None.

WASHINGTON PLAIN AND LOW PLATEAU (Section 16) - In the southwest the plateaus are lower but more intact than elsewhere in the province. They are characterized by extensive plains and broad uplands with little dissection.

16a. Nielsen lowland

Topography: Rolling to hilly, dissected, scoured plain; altitude, sea level to 650 feet; relief 10 to 300 feet; irregular hills of northern part reflect scouring along north-south and northwest-southeast trending joints; marginal channels up to 300 feet deep extensive in southern part.

Drainage: Three large lakes, numerous small ones encompassing 2 sq. miles; drainage pattern irregular, poorly developed; in northern part, where erosion along joints prominent, pattern subrectangular.

Ice caps and glaciers: None.

Soil: Northern part, extensive bedrock with large boulders; southern part, stony, sandy silt.

Permafrost: Continuous; no surface features.

Area of subsection: 55 sq. miles.

Bedrock: Ordovician dolomite and shale; gentle dip to north.

References: None.

16b. Adam plateau

Topography: Flat-topped, little dissected plateaus; upland altitude 650 to 2,000 feet; upland relief, 10 to 100 feet; major valleys, up to 325 feet deep.

Drainage: Four lakes encompassing 4 sq. miles; streams spaced 1/2 to 2 miles in dendritic pattern.

Ice caps and glaciers: 12 ice caps cover 270 sq. miles; largest covers 75 sq. miles.

Soil: Stony, sandy silt till extensive; rubble and block fields, local; talus on flanks of major valleys.

Permafrost: Continuous; poorly developed polygons; localized shallow, depressed edge polygons, up to 300 feet per side.

Area of subsection: 1,370 sq. miles.

Bedrock: Ordovician dolomite and shale; gentle dip to north.

References: Kane, 1856; Koch, 1926, 1927, 1928a, 1929; Malaurie, 1968; Rasmussen, 1919, 1921.

16c. Romer plateau

Topography: Rolling, dissected plateau; altitude 1,000 to 3,100 feet; relief 300 to 1,300 feet.

Drainage: Nine large glacial-dammed lakes encompassing 60 sq. miles; Romer Sø covers 27 sq. miles; streams spaced 1 to 3 miles in poorly developed dendritic pattern.

Ice caps and glaciers: Two ice caps encompassing 55 sq. miles.

Soil: Stony, sandy silt; local rubble and block fields; eastern part cobbly, silty sandy till.

Permafrost: Continuous; poorly developed polygons except in eastern till where depressed-edge polygons up to 200 feet per side occur.

Area of subsection: 875 sq. miles.

Bedrock: Cambrian and Ordovician dolomites; gentle dip to north.

References: Koch, 1929; Malaurie, 1968.

16d. Daugaard-Jensen plain

Topography: Rolling plain with isolated rounded hills; altitude, 1,300 to 1,600 feet, hilltops up to 2,900 feet; relief 30 to 100 feet on plain, up to 1,300 feet on hills.

Drainage: 17 lakes encompassing 20 sq. miles, largest lake, 18 sq. miles; streams spaced 1 to 3 miles in dendritic pattern.

Ice caps and glaciers: None.

Soil: Stony, silty sand; small rubble fields on hills.

Permafrost: Continuous; in eastern part, well developed, depressed-edge polygons with sides up to 300 feet.

Area of subsection: 670 sq. miles.

Bedrock: Ordovician shale and dolomite; gentle dip to north.

References: None.

EAST GREENLAND CALEDONIDES

The alpine mountains and plateaus along the east coast of Greenland are a counterpart of those along the north coast; geomorphic forms are similar, and the gross pattern of mountains and plateaus is also similar.

Kronprins Christian mountains province

The mountains along the east coast of northern Greenland consist of an alpine range near the coast and behind which are a series of complex mountains grading westward into plateaus. The alpine mountains are covered by an extensive ice sheet (fig. 14) and the complex mountains contain several large ice caps.

CAROLINE MATHILDE ALPS (Section 21) - These alpine mountains extend from northern Lambert Land northward to about 81° N. where they are completely covered by an ice sheet. They are cut by numerous valley glaciers which drain upland icefields.

Topography: Alpine mountains; altitude, 2,600 to 5,700 feet; relief, along coast, up to 4,600 feet and in interior, up to 2,600 feet; slopes 30° to vertical on ridges and spurs except along Vandredalen, where 10° to 30° slopes extensive.

Drainage: Few lakes or rivers; valleys occupied by glaciers.

Ice caps and glaciers: Valley glaciers and small mountain ice caps cover 75 percent of area extending to sea level.

Soil: Mainly bare rock; small area of frost-rived rubble.

Permafrost: Continuous; no surface features.

Area of subsection: 2,000 sq. miles.

Bedrock: Folded, metamorphosed nappes of Proterozoic and Paleozoic quartzite, marble, and schist.

References: Dastrup, 1945; Fränkl, 1954a; Fränkl, 1956b; Nielsen, 1941.

WESTERN MOUNTAIN SECTION (Section 22) - The western mountains are along the frontal portion of Caledonian nappe sheets. They are subalpine in nature and grade westward into plateaus. In the area adjacent to the Caroline-Mathilde Alps, the mountains are high and cut into a series of triangular faces. To the south they are high and rounded, and along the western part they are truncated by an upland surface concordant with that of the plateau to the west.

22a. Keglen mountains

Topography: Rounded, discontinuous ridges and spurs; short segments of cliffs along transverse valleys; altitude, 2,000 to 4,700 feet; relief, 1,300 to 4,100 feet; slopes, 15° to 45°; summits rounded to flat with slopes of less than 10°.

Drainage: Five glacial-dammed lakes up to 1 sq. mile in size; transverse streams, spaced $\frac{1}{2}$ to 6 miles, up to 6 miles long; longitudinal streams, spaced $\frac{1}{2}$ to 6 miles, up to 2 miles long, in trellis pattern.

Ice caps and glaciers: 13 ice caps cover 140 sq. miles; north end covered by western edge of Flade Isblink, 100 sq. miles.

Soil: On slopes, mainly bare rock, some talus; upland primarily angular residual rocks in matrix of sand and silt.

Permafrost: Continuous; few areas of poorly developed polygons.

Area of subsection: 900 sq. miles.

Bedrock: Folded nappes of Proterozoic sandstone and Ordovician limestone and dolomite.

References: Davies and Krinsley, 1961; Dastrup, 1945; Fränkl, 1954a, 1956b; Nielsen, 1941.

22b. Finderup piedmont

Topography: Rolling lowland with rounded hills and ridges; altitude, sea level to 2,400 feet; relief, 100 to 1,300 feet; slopes, 5° to 30°.

Drainage: 25 lakes encompassing 20 sq. miles; individual lakes up to 1½ sq. miles; longitudinal streams spaced 2 to 3 miles and transverse streams spaced 1 to 3 miles in trellis pattern.

Ice caps and glaciers: Eight ice caps encompass 75 sq. miles; three ice caps up to 20 sq. miles each.

Soil: Extensive bedrock with scattered rubble cover; silty sand till covers 35 sq. miles; primarily in northern part of subsection.

Permafrost: Continuous; in till area, poorly developed, irregular, depressed-edge polygons.

Area of subsection: 250 sq. miles.

Bedrock: Nappes of Proterozoic to Ordovician sandstone and dolomite.

References: None.

22c. Eastern Alexandrine plateau

Topography: Flat upland, extensive ice cap cover, bounded by high scarps on all but south side where graded to a sloping plain; east and north flanks cut by short streams in narrow canyons; altitude, 2,000 to 3,800 feet; relief, 650 to 2,000 feet.

Drainage: Few lakes on ice cap, none on land area; primarily short segments of headwaters of trellis pattern streams except in north where Vendedalen drains the interior; in Vendedalen, trellis pattern with transverse segments, spaced 1 to 2½ miles, longitudinal segments 1 to 2 miles, master stream braided in lower part.

Ice caps and glaciers: Two ice caps cover 75 sq. miles; two smaller ice caps cover 35 sq. miles.

Soil: Upland, primarily rubble except extensive sandy silt outwash in south.

Permafrost: Continuous; no surface features.

Area of subsection: 575 sq. miles.

Bedrock: Widely spaced nappes of Ordovician dolomite.

References: Adams and Cowie, 1953; Fränkl, 1954a, 1955b; Needleman, 1962.

22d. Skallingen upland

Topography: Rounded ridges and hills; complex morainal ridges up to 10 miles long on upland along western edge of subsection.

Drainage: Eight lakes covering 80 sq. miles of which Blaasø covers 32 sq. miles; irregular, disturbed dendritic stream pattern; tributaries up to 12 miles long, subparallel, spaced 1/2 to 2 miles.

Ice caps and glaciers: Three small ice caps encompassing 45 sq. miles.

Soil: Hill and ridge tops, rubble in sandy silt matrix; lowlands, primarily stony, silty sand; along western edge, extensive thick sandy silt till.

Permafrost: Continuous; in till area, irregular, poorly developed raised center polygons.

Area of subsection: 1,000 sq. miles.

Bedrock: Widely spaced nappes of Ordovician limestone and dolomite.

References: Davies and Krinsley, 1961; Fränkl, 1954a, 1955b; Needleman, 1961, 1962.

East Greenland uplands province

This province in northern Greenland consists of only one section. It lies east of the Caroline Mathilde Alps and is covered extensively by ice caps. The land on the periphery of the ice cap is plateau-like and is underlain by a complex of metamorphic rocks. Southward along the east coast this province expands greatly and contains a variety of metamorphic landforms.

LAMBERT-HOVGAARD HIGHLAND (Section 31)

Topography: Rounded hills and ridges, low morainal ridges in central part of Lambert Land, low cliffs along segments of coast; altitude, sea level to 3,200 feet; relief, 50 to 2,000 feet; slopes on flanks 2° to 15°.

Drainage: Six lakes along margin of Zacharias Isstrøm, largest 3/4 sq. mile, six small lakes inland, total lake area 470 sq. miles; valleys gently sloping, smooth walls; irregular trellis drainage pattern disarranged by glaciation; longitudinal streams, spaced 2 to 5 miles, transverse streams spaced 1½ to 5 miles.

Ice caps and glaciers: Hovgaard Ø and Holm Land covered by large ice caps; four small ice caps on Lambert land and Norske Øer; ice caps cover 600 sq. miles.

Soil: Stony, sandy silt except on rubble-covered summits of high hills and ridges.

Permafrost: Continuous; few surface expressions.

Area of subsection: 1,250 sq. miles.

Bedrock: Proterozoic quartzite, folded and metamorphosed with basalt intrusives and gneiss.

References: Amdrup, 1913; Koch, 1917; Mikkelsen, 1913, 1922, 1957; Nielsen, 1941; Rodahl, 1948.

Northeast Foreland plateaus province

The plateaus of northeastern Greenland merge without distinction into the North Greenland Foreland plateaus and plains. In northeast Greenland, however, the plateaus are cut by a greater number of interconnecting valleys and are mainly large mesa.

MYLIUS ERICHSEN TABLELAND (Section 41) - This tableland, composed of numerous large mesa, makes up most of the Northeast Foreland plateaus. In the southeast part of the section, the plateaus have been eroded extensively and grade into plains.

41a. Hagen-Danmark plateau

Topography: Concordant, flat-topped plateaus cut into large mesa-like blocks, 4 to 9 miles long per side; blocks generally bounded by high scarps with steep basal talus slopes; altitude 2,000 to 4,600 feet; relief, 650 to 3,000 feet.

Drainage: 50 lakes, mostly on interior lowlands cutting the plateaus, largest Femte Maj Søen, 27 sq. miles; major valleys trend northeast, flat-floored with thick alluvial deposits (Interior Lowlands); most tributaries in narrow deep canyons; extensive lowlands at head of Danmark Fjord; trellis drainage pattern with northeast trending longitudinal streams, 3 to 5 miles apart and transverse streams 2 to 3 miles apart.

Ice caps and glaciers: Ice caps, up to 90 sq. miles maximum size on upland; ice cap total area 520 sq. miles.

Soil: Upland, rubble fields, coarse frost-rived blocks and slabs; near Greenland Ice Sheet and Centrum Sø, extensive cobble, sandy silt moraines.

Permafrost: Continuous; raised center, rectangular, polygons, with sides up to 200 feet common along Greenland Ice Sheet.

Area of subsection: 5,000 sq. miles.

Bedrock: Cambra-Silurian dolomite and limestone; gentle dip to north.

References: Adams and Cowie, 1953; Amdrup, 1913; Davies and Krinsley, 1961, Freuchen, 1915; Holmen, 1957, Knuth, 1958; Koch, 1917, 1939; Mikkelsen, 1913, 1922, 1957; Needleman, 1961, 1962; Rasmussen, 1915, 1957; U. S. Army Transportation Board, 1960.

41b. Sjaelland plateau

Topography: Undulating plateau grading to broad interior lowland, dissected only along south and northwest flanks; low kames and ridge moraines on upland; altitude 300 to 2,600 feet; relief up to 300 feet along Danmark Fjord, 1,000 feet along Centrum Sø.

Drainage: 14 lakes cover 10 sq. miles; dendritic drainage pattern with trunk streams 9 to 15 miles long, spaced 6 to 12 miles and tributaries spaced 2 to 3 miles.

Ice caps and glaciers: One ice cap covering 20 sq. miles of this area and extending into Alexandrine Plateau (Unit 22c).

Soil - Poorly sorted sandy silt; few isolated morainal ridges of stony sandy silt.

Permafrost: Continuous; no surface expression on upland; along west flank of plateau, extensive depressed edge irregular polygons with sides up to 50 feet.

Area of subsection: 860 sq. miles.

Bedrock: Cambro-Ordovician dolomite and sandstone; gentle dip to north.

References: Adams and Cowie, 1953; Mikkelsen, 1913, 1922, 1957; Needleman, 1962.

41c. Palnatoke strand

Topography: Gently sloping coastal lowland and delta terrace up to $2\frac{1}{2}$ miles wide; altitude, sea level to 600 feet; relief up to 75 feet on low morainal ridges and marginal drainage channels.

Drainage: No lakes; streams trending northwest, spaced $\frac{1}{2}$ to 1 mile in parallel pattern.

Ice caps and glaciers: None.

Soil: Stony, sandy silt till and moraine except along beaches and on delta terrace where pebbly sand and cobbly sand are dominant (fig. 15).

Permafrost: Continuous; few surface forms; rectangular and pentagonal depressed-edge polygons with sides up to 200 feet present on delta terrace.

Area of subsection: 25 sq. miles.

Bedrock: Ordovician dolomite; gentle dip to north.

References: Knuth, 1958; Mikkelsen, 1913, 1922, 1957.

VALDEMAR GLÜCKSTADT PLAIN (Section 42)

The northern side of the tableland in northeast Greenland has been eroded extensively and is now a rolling plain covered with thick deposits of glacial till and ridge moraine. Although it has many characteristics of the landforms assigned to the Danelagen strand, it has been retained as part of the Foreland plateaus because of its dominant bedrock structure and because of the high relief along Danmark Fjord.

Topography: Rolling to hilly lowland, scarps up to 150 feet high common in northwest part of plain; altitude, sea level to 1,200 feet; relief up to 300 feet.

Drainage: Numerous lakes in southern half of plain, small thaw lakes in southwest, $5\frac{1}{2}$ sq. miles total lake area; trunk streams of trellis pattern spaced 3 to 12 miles, up to 18 miles long, tributaries spaced $\frac{1}{2}$ to 4 miles.

Ice caps and glaciers: None.

Soil: Till plains and low morainal ridges, stony, sandy silt; beach along Hagen Fjord and Independence Fjord, cobbly sand.

Permafrost: Continuous; few surface features except in southwest thermokarst area (fig. 16).

Area of subsection: 470 sq. miles.

Bedrock: Cambro-Silurian dolomite; Pennsylvanian-Permian sandstone on north half along Danmark Fjord; dip gentle to northeast.

References: Amdrup, 1913; Freuchen, 1915, Holmen, 1957; Koch, 1917; Mikkelsen, 1913, 1922, 1957; Rasmussen, 1915, 1957.

EAST GREENLAND HINTERLAND PLATEAUS

On the east side of the East Greenland Caledonides mountains and the southeast end of the mountains of northern Greenland, there is an area of separated, moderately eroded plateaus. In northern Greenland the division is a small, isolated part of a system that is extensive in central-east Greenland.

Northeastern coastal plateau province

This is the only physiographic province in the northern Greenland part of the East Greenland Hinterland Plateaus. Because of the topographic variety in the plateaus, the province is divided into four sections and seven subsections.

HERLUF TROLLE UPLAND (Section 52) - This upland lies at the southeast end of the northern Greenland mountains. On the east, the upland is a series of small plateaus developed on flat-lying sedimentary rocks; to the west, these rocks are tilted and form a small-scale basin and range type of landform.

51a. Kim Fjeld

Topography: Rounded plateau, 20 percent of upland intact; altitude 2,000 to 2,100 feet; relief about 1,000 feet; frontal slopes up to 60°, local scarps.

Drainage: Longitudinal trunk streams of trellis pattern 2½ to 3½ miles apart, transverse streams 1 to 2 miles apart.

Ice caps and glaciers: Three small valley glaciers encompassing 1 sq. mile.

Soil: Shallow sandy silt and rubble, talus at base of slopes.

Permafrost: Continuous; no surface features.

Area of subsection: 45 sq. miles.

Bedrock: Pennsylvanian - Permian sandstone and shale; horizontal beds except along west edge where dip changes abruptly and steeply to west.

References: Amdrup, 1913; Koch, 1917, 1926, 1927, 1928a, 1935.

51b. Ladegaardsaaen hills

Topography: Block-fault hills and ridges; steep fronts to east and northeast, gentle back slopes; altitude, 1,150 to 2,000 feet; relief, 100 to 300 feet; hills up to 1,300 feet long, ridges up to 5 miles long.

Drainage: Parallel trunk streams of irregular drainage pattern, 1 to 2 miles apart, tributaries ½ to 1 mile apart.

Ice caps and glaciers: None

Soil: Ridges and hills, shallow, stony, sandy silt and rubble; valleys, deep, pebbly to cobbly, silty sand.

Permafrost: Continuous; no surface features.

Area of subsection: 35 sq. miles.

Bedrock: Permian sandstone in block faults dipping 10° to 30° to southwest and west.

References: Davies and Krinsley, 1961.

51c. Interior low plateau

Topography: Rolling upland, shallow valleys with gently sloping walls; altitude, 650 to 1,300 feet; relief, 150 to 500 feet, except along major valleys where relief is up to 1,000 feet.

Drainage: Single trunk stream of trellis pattern, parallel tributaries spaced ½ to 3½ miles.

Ice caps and glaciers: None.

Soil: Pebbly to cobbly silty sand.

Permafrost: Continuous; no surface features.

Area of subsection: 36 sq. miles.

Bedrock: Permian sandstone; horizontal beds.

References: None.

HERLUFSHOLM STRAND (Section 52) - This strand is a continuation of the Arctic strand. It is separated from the latter because of the great increase in glacial deposits on the Herlufsholm strand as well as a more artificial separation because of province boundaries.

Topography: Gently sloping coastal lowland up to 12 miles wide; altitude sea level to 1,000 feet; relief up to 100 feet except in south where relief is up to 500 feet; 11 raised beaches on strand; relief along steep front between beaches 6 to 30 feet (fig. 7).

Drainage: Irregular drainage pattern, streams flow transverse to strand, spaced 2 to 4 miles.

Ice caps and glaciers: None.

Soil: Pebbly and cobbly coarse sand.

Permafrost: Continuous; few surface features; poorly developed, shallow, depressed-edge polygons up to 200 feet per side.

Area of subsection: 100 sq. miles.

Bedrock: Folded, steeply dipping, Proterozoic-Silurian sandstone and dolomite, some shale.

References: Amdrup, 1913; Davies and Krinsley, 1961; Holmen, 1957; Knuth, 1951; Koch, 1917, 1923, 1926, 1927, 1928a, 1935; Laursen, 1954; Troelson, 1952.

DIJMPHNA-INDEPENDENCE UPLAND (Section 53) - The plateaus and lowlands near the mouth of Independence Fjord and along the east coast of Amdrup and Holm Lands form the major part of the northeast coastal plateau province. On the east coast the plateaus are rounded and the upland is covered by small ice caps. In the north end of Kronprins Christian Land, Flade Isblink, a large ice cap covers most of the plateau and extends to the sea except for short segments of the coast where the rocks of the plateau are exposed.

53a. Kilen-Ingeborg plateau

Topography: Domed upland, mainly covered by Flade Isblink; upland a dissected rounded plateau; altitude sea level to 2,400 feet; relief, 60 to 300 feet.

Drainage: Numerous small lakes on Prinsesse Ingeborg Halvø; three lakes in inner part of plateau, total lake area 4 sq. miles; valleys narrow, steep-sided, local canyons; streams in parallel pattern, spaced ½ to 3 miles.

Ice caps and glaciers: one large icefield covers 1,800 sq. miles.

Soil: Pebbly and cobbly silty sand on upland.

Permafrost: Continuous, few surface features.

Area of subsection: 4,000 sq. miles.

Bedrock: Permian to Cretaceous shale and sandstone; horizontal bedding.

References: Amdrup, 1913; Holmen, 1957; Koch, 1917, 1939; Mikkelsen, 1913, 1922, 1957; Nielsen, 1941; Rodahl, 1948.

53b. Danelagen strand

Topography: Coastal lowland, ½ to 5 miles wide, includes Prinsesse Thyras Ø, Prinsesse Dagmar Ø, Prinsesse Margarethe Ø; gently sloping plain except on islands where plain is domed and gently sloping; altitude, sea level to 400 feet; relief up to 75 feet; raised beaches on island flanks and all other lowlands, 3 major levels, up to 125 feet.

Drainage: Five lakes on Prins Frederick Øer in bedrock basins; short streams, less than 5 miles long, spaced 1 to 3 miles in subparallel pattern.

Ice caps and glaciers: Small ice cap on southern Prinsesse Margarethe Ø, 18 sq. miles.

Soil: Raised beaches, pebbly and cobbly sand; island uplands pebbly and cobbly sandy silt.

Permafrost: Continuous; few surface features.

Area of subsection: 315 sq. miles.

Bedrock: Pennsylvanian-Permian sandstone and shale; horizontal beds.

References: Amdrup, 1913; Holmen, 1957; Koch, 1917; Mikkelsen, 1913, 1922, 1957; Rodahl, 1948.

53c. Knud den Stores plateau

Topography: Isolated plateau covered by small ice cap; smooth upland; side slopes 30° to 45° near top, 10° to 20° on lower flanks; altitude 2,100 feet; relief 650 feet.

Drainage: Parallel pattern, streams spaced ½ to 3 miles, less than 5 miles long.

Ice caps and glaciers: Single ice cap, 35 sq. miles.

Soil: Upland, stony, silty sandy soil; talus on flanks.

Permafrost: Continuous; no surface features.

Area of subsection: 75 sq. miles.

Bedrock: Ordovician dolomite; gentle dip to north.

References: None

53d. Holm-Andrup plateau

Topography: High plateau, in two segments; upland, flat to rolling, covered by extensive ice caps; scarps along flanks; talus at base of scarps; altitude, 600 to 3,500 feet.

Drainage: Poorly developed trellis pattern on Amdrup Land, trunk streams $\frac{1}{2}$ to 6 miles apart, short parallel streams on Holm Land, $\frac{1}{2}$ to 3 miles apart.

Ice caps and glaciers: Large and small ice caps cover 1,300 sq. miles of Holm Land; one large and two small ice caps cover 2,000 sq. miles of Amdrup Land.

Soil: Upland rubble; rolling plateau in southern Amdrup Land, stony silty sand.

Permafrost: Continuous; no surface features.

Area of subsection: 750 sq. miles.

Bedrock: Pennsylvanian sandstone; horizontal beds.

References: Amdrup, 1913; Koch, 1917; Mikkelsen, 1913, 1922, 1957; Nielsen, 1941; Rodahl, 1948.

GREENLAND SEA STRAND (Section 54) - The coastal lowland along the northeastern coast of Greenland is narrow and discontinuous. It is a wave-eroded flat covered with deposits forming raised beaches and delta terraces.

Topography: Gently sloping coastal lowland; raised beaches along most of lowland, 17 to 25 levels ranging up to 160 feet; relief up to 50 feet along beach terrace fronts.

Drainage: Shallow valleys, less than 25 feet deep; streams spaced $\frac{1}{2}$ to 5 miles apart in parallel pattern.

Ice caps and glaciers: None.

Soil: Cobbly and pebbly sand.

Permafrost: Continuous; rectangular, depressed-edge polygons, up to 200 feet per side, edges depressed 10 to 20 inches.

Area of subsection: 90 sq. miles.

Bedrock: Pennsylvanian sandstone, horizontal beds; some Proterozoic metamorphic rocks.

References: Amdrup, 1913; Koch, 1917, 1939; Nielsen, 1941; Rodahl, 1948.

INTERIOR LOWLANDS

The interior lowlands have been shown separately because of their extent, common form, and in order to indicate a general pattern of the mesa-like development of the tablelands. These lowlands are developed in all the physiographic provinces and commonly cross from one province or section into another.

Topography: Broad alluvial and glaciated valleys, $\frac{1}{2}$ to 4 miles wide; flat valley floors except southern part of Vandredalen, in badlands of thick silt deposits (fig. 18); altitude sea level to about 1,000 feet; relief 25 to 300 feet; highest along fronts of river terraces; up to 75 feet in badlands.

Drainage: Numerous lakes on lowlands in Washington-Christensen and Mylius Erichsen tablelands, maximum size 4 sq. miles, total lake area 230 sq. miles; major streams braided with beds up to 2 miles wide.

Ice caps and glaciers: None.

Soil: Well sorted, packed, rounded gravel with cobbles up to 4 inches, gravel up to 50 feet thick; southern end of Vandredalen, clay-silt soil covers 18 sq. miles.

Permafrost: Continuous; 4- and 5-sided, shallow-depressed-edge polygons with sides to 150 feet long common on gravel.

Area: 3,200 sq. miles.

Bedrock: Varies according to subsection in which lowlands occur.

References: Cited under subsections in which lowlands occur.

TERRAIN OF NORTHERN GREENLAND

Terrain classification in contrast to physiographic division is based primarily on topographic form without regard to common geologic history or continuity. Thus, if two landforms are similar in character even though the rock on which they develop is dissimilar and the histories of erosion from which the landforms developed are totally different, they would be classified in the same terrain category. The dominant feature considered in this classification is topographic form modified by relief, slope, and to some extent microrelief.

Based on the above criteria the terrain of northern Greenland has been classified into seven categories (plate 2 and table 1). Three of the units pertain to lowlands, three to hills, and one to mountains and plateaus. Normally, the last would be subdivided into at least two and possibly three units distinguishing the terrain features typical of alpine mountains, rounded mountains, and mesa-like plateaus. Since the emphasis of this study is towards cross-country operation of air-cushioned vehicles, this distinction has not been made as all three types of terrain are similar in restricting movement. Most plateaus have relatively smooth uplands, which have been classified here as plains since this reflects their true terrain form. The steep sides surrounding these smooth areas have been placed in the same category as alpine mountains, because of their steep slopes.

Shore ice conditions along the coast and in fjords have been included as terrain because of the continuity of land-sea features in northern Greenland. Because of continual movement of sea ice and relative stability of shore ice, there is generally a narrow zone of disturbed ice along the coast in all parts of northern Greenland. This disturbance results in pressure ridges, from a few feet to over 40 feet in height. The exact position of the disturbance varies from year to year, but the general area of occurrence does not vary significantly.

Icebergs are common in most of the fjords and occur in local concentrations around the mouths of Independence and Hagen Fjords. The areas of concentration depend on winds and currents but change very little from year to year. In the area of Prinsesse Dagmar, Thyras and Margarethe Øer there are large tabular masses of ice, either remnants of former shelf ice or fragments broken off Flade Isblink (Helk and Dunbar, 1953). The position of these masses has remained fixed since their discovery 20 years ago.

Tides in northern Greenland have a very small range (Lundbak, 1962). Short duration observations made at Thank God Havn, Kap Bryant, Kap Morris Jesup, Jørgen Brønlund Fjord, and Kap Holbæk indicate a maximum tidal range of 1 to 2 feet except on the north coast, where the

range is as low as 2 inches. At Station Nord, near the mouth of Independence Fjord, the range is about 1.16 feet. On the west coast, at Thank God Havn, the range is 2.16 feet.

A prominent lead in the ice exists from 5 to 30 miles offshore from the Greenland Sea into Wandel Hav terminating off Kap Morris Jesup. This lead varies in form from year to year but it is generally from a mile to 20 miles wide and comes near shore at Nordostrundingen. The Soviet vessel "Ob" has apparently made use of this lead in attaining high latitudes on several voyages (Schytt, 1957).

The relations between the Greenland ice sheet and the adjacent land area change very little throughout the years. Cliffs and steep slopes are along the terminus of most of the ice sheet. In some areas, however, the ice sheet grades abruptly or gently into the land. Where such gradations are 30 percent or less, they have been shown as ramps (plate 2A-D). The ramps vary in width from a couple of hundred feet to several miles. Some are formed of drifted snow, others are hard, blue ice, and all persist from year to year.

GEOMORPHOLOGY OF SELECTED AREAS

The geomorphology of five areas depicted at scales of 1:100,000 or larger in Plates 3 through 7 includes most of the landforms and physiographic types found in northern Greenland. Polaris Forbjerg (plate 3) is typical of the inland plains and hills that form the Hall-Nares trough; Herlufsholm strand (plate 4) is an example of the coastal flats along the Arctic strand; Valdemar Glückstadt Land (plate 5) displays the major features of heavily glaciated plains; Mylius Erichsen Land (plate 6) contains the major characteristics of the mesa-like plateaus and complementary broad, glaciated through valleys; and Skjoldungelv (plate 7) is one of the larger glaciated plains with broad alluvial valleys along the front of the ice sheet. The only major topographic form not included is alpine mountains. Such areas have only a few minor variations in their topographic forms and they are almost entirely unsuitable overland movement.

Polaris Forbjerg

Polaris Forbjerg on the northwest coast of Greenland between 81° 15' and 82°00'N. latitude (plate 3).is a part of the Hall-Nares Trough physiographic section. It is characterized by a broad plain trending northeast across the central part of the peninsula bordered by dissected plateaus and rounded mountains on the north and mountain-like plateau remnants on the south (Davies, Needleman, and Klick, 1959).

Polaris Forbjerg shows at least two stages of glaciation. The oldest glaciation was from valley glaciers descending Petermann Fjord on the west and Newman Bugt on the east which spread out to cover the plain and much of the plateau to the north. The latest glaciation was similar in nature but only the edges of the plain up to the Graastenelv and Atka Elv were covered. The outwash from these glaciers eroded and greatly modified the morainal ridges from former glaciation in the central part of the plain.

Bedrock crops out extensively on Polaris Forbjerg and is primarily Ordovician and Silurian limestone and dolomite dipping gently to the northwest (fig. 2). Within the Silurian is a prominent reef biohern that forms the Hauge Bjerge (Dawes, 1971). On the fore side (north) of the reef the Silurian is dominantly shale. In the northern quarter of the peninsula the Ordovician and Silurian rocks are folded into open synclines and anticlines and along the coast of Robeson Channel they form a low rounded mountain ridge trending northeast (fig. 3).

Vegetation is sparse on Polaris Forbjerg and is confined to isolated plants and small patches of grass growing mainly in the area of modified morainal ridges and on river terraces.

Alluvial plains (unit 1) are extensive along the Atka Elv, Graastenelv (fig. 19) and several other large streams. In the area of alluviation the rivers flow in braided channels up to a mile wide and each channel is up to 200 feet in width and 1 to 4 feet in depth. During high water in the melt season, late May and June, the river overflows the channels and the bottom land is flooded from bank to bank. The alluvial bottom lands are formed of rounded pebbles and cobbles with a small amount of sand. The river banks are gravel ledges or sandy clay boulder moraine and are from 8 to 40 feet high. In most places the valley walls slope from 37° to vertical.

The mouth of the Atka Elv forms the only major delta on Polaris Forbjerg. It is cut about 7 feet below the level of the adjacent marine terraces and grades to the sea. Deposits in the delta are primarily silty sand with some pebbles and cobbles.

River terraces (1a) along the west side of Graastenelv and along short segments of Atka Elv are from 7 to 60 feet above the channel of the rivers. The deposits on the terraces are poorly sorted, tightly-packed pebbles and cobbles generally 4 inches or less in size, in a matrix of silt. The surfaces of the terraces are smooth and slope gently downstream. On the terrace along the west side of Graastenelv there are several areas of closely spaced, interconnected channels up to a foot deep and 6 feet wide. Desiccation polygons up to 10 inches on a side cover the terraces (fig. 6). Permafrost is present at a depth of 2 feet and ground ice is at a depth of 36 to 40 inches.

Marine plains and terraces (unit 2) are well developed along Polaris Bugt. The plains and terraces are composed of moderately well-sorted pebbles and cobbles in a sand and silt matrix. Along Polaris Bugt marine terraces are at elevations above sea level of 6, 10, 18, 25-32, 46, and 59-65 feet. On Newman Bugt the elevations are 10, 30-38, 75, 135, and 155 feet. The delta terraces (2a) are similar to the marine plains and terraces and are at the mouths of major streams. Elevations on these terraces are similar to those of the marine plains and terraces.

A small area of dissected plains (unit 3) borders the Atka Elv. The plains are developed on marine clay and silt. They are cut by numerous small stream channels up to 5 feet wide and a foot deep. In addition small lakes are in shallow depressions on the plain. Relief on the plain is up to 20 feet and a miniature badland topography has developed. The areas of the clay-silt plain are wet and the ground is weak, much of it having the consistency of mud. Ground ice is present 2 feet below the surface but no surface configurations typical of permafrost are present.

The most recent glaciation (Würm-Wisconsin) of Polaris Forbjerg left large morainal ridges (unit 4) inland as far as the Atka Elv on

the west and Graastenelv on the east side of the area. The ridges are from a few feet to over 50 feet in height and are composed of pebbles, cobbles, and boulders up to a foot in size, in a matrix of poorly sorted silt and sand. The ridges are arcuate and subparallel in plan and trend north onto the edges of the plateau bordering the central plain. Morainal ridges from a previous, more extensive glaciation are also present on the inner parts of the northern plateau. They are similar in nature to the more recent ones on the plains except they are rounded on their upper parts. Permafrost features are poorly developed on the moraines and are primarily stone nets and circles. Desiccation cracks up to 10 inches on a side are present in areas of low relief.

The central part of the Polaris Forbjerg plain is an extensive area of modified morainal ridges (unit 5). The morainal ridges were formed previous to the Würm-Wisconsin glaciation and were eroded and filled by outwash from the later glaciation. At present the moraines are low mound-like ridges in arcuate belts centered on Newman Bugt and Polaris Bugt protruding a foot to 6 feet above the general surface of the plain (fig. 8). They are rounded and side slopes are less than 30°. The area between the ridges has been filled with marine sandy, silty clay outwash. The moraines are similar in composition to more recent morainal deposits. Ground ice is present at a depth of 27 to 35 inches and poorly developed, irregular polygons with shallow, indistinct depressed edges are present over much of the area of modified morainal ridges (fig. 20).

Outwash plains (unit 7) are developed mainly within the area of modified morainal ridges. They are up to 2 miles wide and 6 miles long. The surface is smooth with practically no relief. The deposits are dominantly silty sand with some gravel in lenses and pockets. Drainage in the outwash plains is poorly developed and only major streams are present. Ground ice is within 2 feet of the surface but there is no surface expression of permafrost.

The mountains and plateaus south of the central plain are covered with an extensive, moderately deep till (unit 8). The till is dominantly silt with scattered pebbles and cobbles. The deposits are from a foot to over 20 feet thick and are draped over the bedrock topography. Relief is up to 200 feet and the upland is rolling to hilly. Ground ice is present in the thicker deposits at a depth of 2 feet or less. Small areas of rectangular, depressed-edge polygons up to 200 feet on a side occur on the till.

Channeled uplands are present in a small area of the plateau near Newman Bugt (unit 9). The channels are parallel and trend north-northeast. They are up to 100 feet deep and are spaced from 30 to 500 feet apart. Most of the channels are separated by low ridge moraines

and the lower part of the channels are cut in bedrock. The walls of the channels have slopes of 37° to vertical and the floors, 10 to 100 feet wide, are strewn with rock debris and boulders.

Although bedrock outcrops (unit 11) are extensive in many areas of the peninsula, bedrock is dominant only in the Hauge Bjerge (fig. 9) and in the northern plateau inland from St. Anthony Naes. The latter area has relief up to a thousand feet and slopes of 45° to vertical are extensive. Talus is present locally at the foot of these slopes. The streams flow transverse to the trend of the bedrock in deep narrow valleys. Current is swift and the streams are from 10 to 100 feet wide with depths up to 2 feet. Much of the surface in this area of bedrock is covered with slabby fragments of limestone.

The Hauge Bjerge are high, rounded, linear plateau remnants that form a mountainous ridge across the lower part of Polaris Forbjerg (fig. 9). Elevations are 2,300 to about 3,000 feet and relief is up to 2,700 feet. The slopes on the flanks of the ridge are 15° to 45° with small areas of cliffs. The mountainous character of this portion of the plateau reflects the reef bioherm complex that fronts to the north along the Hauge Bjerge. The surface of the mountainous upland is covered with frost-rived boulders and slabs mixed with old sandy ground moraine. Major streams cut across the upland in narrow deep valleys with smaller streams in shallow valleys spaced about 1 mile, draining down the fore and back slopes of the ridge.

Valdemar Gluckstadt Land

Valdemar Glückstadt Land is in the northeastern part of Greenland along the south side of Independence Fjord (plate 4). It is a glaciated lowland lying along the edge of the Mylius Erichsen tableland section of the Northeast Foreland plateaus physiographic province. The area is a rolling to hilly plain covered by glacial moraine and outwash. On the south it is bordered by low, mesa-like segments of a dissected high plateau. The plain rises to nearly 1,200 feet elevation on old morainal deposits in the north-central part; elsewhere it is 250 to 1,000 feet. Relief is up to 450 feet in the north-central part of the plain but throughout most of the area relief is on the order of 20 to 100 feet.

The drainage pattern is irregular and reflects several stages of glaciation. Most streams are less than 50 feet wide and up to a foot deep. Many flow only in the melt season in late May and June. Several large rivers in the south drain small ice caps in the plateau adjacent to the plain. They are in braided channels on flat-floored, wide valleys. Permafrost with ground ice is within 1 or 2 feet of the surface throughout Valdemar Glückstadt Land. During the summer most of the soils on side slopes and bottom lands are saturated and have low bearing strength. After freeze-up in late September all soils are firm.

Bedrock crops out in cliffs along Danmark Fjord, in low cliffs south of Bjørnsholm Fjord, and on the flanks of the plateau along the southern end of the plain. It is primarily Cambrian limestone and dolomite with some sandstone except in the southwest corner of the area where late Precambrian (?) dolomite and limestone occur. The Cambrian and Precambrian formations are not folded although the beds dip gently to the northeast. The northeast part of Valdemar Glückstadt Land has Pennsylvanian-Permian sandstone overlying the Cambrian carbonate rocks (Haller, 1970).

Vegetation is extremely sparse in Valdemar Glückstadt Land. Most of the surface is barren with small patches and isolated plants occurring along wet bottom lands. Small meadows of grass and sedges are on the flanks of braided streams and on some of the bottom lands.

Alluvial valleys and deltas (unit 1) with rivers flowing in broad, flat-floored valleys and debouching on coastal deltas are primarily in the southern part of Valdemar Glückstadt Land. The alluvial valleys are generally from 1,000 to 5,000 feet wide but in some sections they extend to over 8,000 feet. The streams are generally braided and channels shift annually during high water in the melt season. The channels are shallow with water from 1 to 4 feet deep in midsummer and banks along the individual channels are up to 4 feet high. The banks along the edge of the valleys are steep and are 10 to 100 feet high. Gradients along the valleys are very gentle and are on the order of 0.8 percent.

The alluvial valleys are covered with cobbles up to a foot in diameter. They are subangular to subrounded in shape. Sand and some silt are present in minor amounts and the deposits are poorly graded. The deposits are from 10 to over 40 feet thick and permanently frozen ground, generally with ground ice, is present at the base of the gravel.

The deltas generally have a steeper slope than the alluvial valleys and rise from the sea on gradients of 1 or 2 percent. Marine terraces border most of the deltas. Materials are similar to those in the alluvial valleys and ground ice is present in the inner parts of the delta at depths of 10 feet or more. Polygons, generally rectangular in shape, up to 100 feet on a side, and with gentle, depressed edges, are present on the flanks of some of the deltas. Ice-push ridges up to 6 feet high are present along the fronts of deltas on Danmark Fjord.

Marine plains and terraces (unit 2) were developed by uplift since the retreat of the Wisconsin glaciers. This rise has been about 160 feet in Valdemar Glückstadt Land. On the flanks of prominent deltas along Danmark Fjord the rise is reflected in two major terrace levels at 60 to 80 feet and at 160 feet. Along Hagen and Independence Fjords, there are no distinct terraces but a series of elevated beach ridges are 80 to 130 feet above present sea level.

The terraces have nearly flat surfaces bounded by faces that slope at 15° to 30°. Material in the terraces is poorly graded sand and gravel. Pebbles in the gravel, up to 1 inch in diameter, form about half of the deposit. Gravel larger than 1 inch forms less than 10 percent of most deposits and the maximum diameter of cobbles is seldom greater than 6 inches.

The strand lines are closely spaced; in the vicinity of Kap Ludovika there are 17, spaced about 6 to 10 feet vertically. Each strand consists of a ridge of shingle gravel 1 to 4 feet high lying on low bluffs and gently sloping coasts.

Ground ice is present within 2 feet of the surface beneath terraces and strand line deposits. On the terraces rectangular polygons 50 to 100 feet on a side with depressed edges are present.

In several areas along the coast on Hagen Fjord there are dissected plains formed on thick deposits of silt and clay (unit 3). However, the deposits are large enough to be a distinct topographic entity only in the area adjacent to the delta of the large river entering Hagen Fjord in the southern part of Valdemar Glückstadt Land. Badland topography is typical of the silt and consists of irregular drainage patterns, short steep-sided gullies, and highly dissected uplands. Relief is from 10 to 60 feet and the upland is 60 to 80 feet in elevation. The clay-silt has little gradation and contains practically no sand or gravel except as a thin cover. It is very thinly bedded, resembling varves. Ground ice is present at a depth of a foot or two. The surface is free of frost features but contains polygonal desiccation cracks, up to 6 inches in size that extend to ground ice.

Three distinct stages of glaciation are apparent in Valdemar Glückstadt Land. The deposits of the older stages have been highly modified by erosion from successively later stages. Continuous systems of distinct morainal ridges (unit 4) are related only to the latest stage and occur along the coastal fringe of Dunmark and Independence Fjords. Along Hagen Fjord the ridges are up to 4 miles inland along the northern part of Valdemar Glückstadt Land and 6 miles inland in the southern part.

The ridges are straight to arcuate in plan and single ridges are up to 7 miles long. In areas of maximum development six to eight parallel or subparallel ridges are present. Ridges are from 20 to 160 feet high and the side slopes are 15° to 40°. The moraine is dominantly gray clay and fine sand with cobbles and boulders. Ground ice is present 1 or 2 feet below the surface in the ridges and the adjacent troughs. In general, no surface expression of permafrost is present on the morainal ridges but the troughs between ridges have solifluction features near the base of the ridges.

Most of the central and southeastern parts of the area are made up of deposits from an older glacial stage. Traces of morainal ridges are distinct but the ridges are modified to low hills with gentle

rounded surfaces (unit 5). Swales between the ridges have been filled with outwash, relief is generally less than 40 feet and slopes seldom exceed 20°. Numerous small lakes are present in the area of modified moraines and the streams are mainly small and sluggish except for the large, braided rivers draining ice caps to the south. The material in the moraines is similar to that in the younger morainal ridges but the pattern of the ridges contrasts greatly with the younger ones. The general trend of the older moraine is northeast with short east-trending segments. Along Danmark Fjord some of the older ridges are truncated by younger ridge moraines. In the south central part of the area some large but highly eroded and buried moraines extend in wide arcs parallel to the arcuate younger moraines along Hagen Fjord. Their form and general state of erosion suggest that they are related to second generation, modified moraines.

Permanently frozen ground with ground ice is present at a depth of 1 to 2 feet. There is very little surface expression of the permafrost even though much of the area is wet in summer.

The modified moraines along Independence Fjord (unit 5a) have been reduced to low, elongated mounds that trend northeast across a sloping coast. The mounds are less than 20 feet high and side slopes are 15° or less. The area is cut by numerous shallow ravines spaced 1,000 to 4,000 feet in a northeast trend.

The northeast and north-central parts of Valdemar Glückstadt Land comprise a hilly upland with summits of major hills at 800 to nearly 1,200 feet. The hills are old, highly modified hummocky moraines (unit 6) probably representing the oldest stage of glaciation in the area. The general trend of the hills is to the northeast except along the southwest part of the area where they trend southeast gradually curving east and eventually northeast. Relief is 120 to 240 feet. The hills are rounded with side slopes of 10° to 20°. Along the periphery of the area of hummocky hills, streams have cut into the moraines to depths of 120 feet. The moraine is probably on the order of 400 to 600 feet thick based on the profiles distinguishable along Danmark Fjord. It is dark gray to gray-brown clay and sand with rounded cobbles and boulders.

Ground ice is present within 2 feet of the surface. Rectangular depressed-edge polygons are present on many of the flatter hilltops. During summer the soil is dry on the tops and sides of hills except in small, isolated depressions. Bottom lands are wet and soft.

There are three large outwash plains (unit 7) on Valdemar Glückstadt Land. The largest and apparently oldest one lies along the north side of the hummocky morainal hills. Smaller ones related to the latest stage of glaciation are in the southeast and southwest part of the area. The outwash plains are smooth to undulating. The younger

plains have relief of less than 20 feet except along major valleys that cut through them or adjacent to low, modified morainal ridges that are surrounded by the outwash. The older plain is more highly dissected and has a rolling upland with relief up to 80 feet.

Drainage is very irregular on the older plain because it is in the headwater areas of a number of small streams. Valleys are broad and shallow, with numerous wet spots. The younger plains have small, short streams in shallow valleys draining into major streams that cut across the plains.

Soils are sands with gravel and boulders and are poorly graded. Ground ice is within a few feet of the surface and frost boils, stone rings, and stripes are present on the surface. On some parts of the plains irregular depressed-edge polygons up to 200 feet on a side are present.

The low plateau along the southern end of Valdemar Glückstadt Land is covered to a great extent by small ice caps. The upland along the periphery of the ice caps is flat to gently sloping with an undulating surface and is covered by a thin veneer of till (unit 8). The upland is 1,000 to 1,600 feet in elevation and relief is less than 30 feet except along the sides of major valleys where it is as much as 200 feet. In the western part these uplands are bounded by bedrock cliffs but in the east they grade into adjoining outwash and morainal plains on gradients of 2 to 6 percent.

The veneer of till on the uplands is from a foot to about 10 feet thick, the thickest on the lower slopes in the east. It is composed of boulders and cobbles in a matrix of sandy silt. Mixed with the till, especially in the west, are angular, frost-rived boulders and cobbles.

Drainage is by large streams flowing across the upland from the ice caps. The upland itself contains only very small, widely spaced streams that flow in irregular shallow valleys.

Ground ice is present throughout the upland at a depth of 1 or 2 feet. At the surface there are none of the distinct forms usually associated with permafrost. During the summer the soils are wet and weak in low spots on undulating surfaces.

On the flanks of the plateau in the southeastern and southwestern part of the area, channelling along former glacier fronts is extensive. The area of channelling in the southwest is cut into bedrock on the plateau (unit 9). Here the channels are arcuate and in subparallel sets. Individual channels are spaced 100 to 400 feet and are up to 200 feet wide and 100 feet deep. The walls of the channels slope 37° to vertical. Between the channels the upland is covered by stony till

and low morainal ridges. The floors of many of the channels are strewn with rock debris that has fallen or rolled from the walls. Included in this part of the channelled uplands are small areas of plateau adjacent to several small ice caps. Stony till a few feet thick covers the plateau, and scree slopes on the flanks of the plateau are extensive.

The channelled upland in the southeast is cut into bedrock but the channels are irregular in plan and are widely spaced, 500 to 3,000 feet apart. The channels are up to 200 feet deep and are 500 feet or more in width. The sides of the channels slope from 20° to 60°. Talus covers most of the sides of the channel and rock debris is on the floor. The upland between the channels is primarily a veneer of stony till up to 10 feet thick.

A third area of channelling is in a series of old moraines just north of the plateau in the south-central part of Valdemar Glückstadt Land. These channels are subparallel and arcuate in plan. They are spaced 300 to 1,000 feet and individual channels are about 300 feet wide and 40 to 80 feet deep. The sides of the channels slope 15° to 60°. The undulating upland between the channels is composed of sandy clay moraine containing boulders and cobbles.

Drainage in the channelled areas is by many small streams flowing in the channels. Most of these streams are dry except during the melt season.

Permafrost is present in the channelled areas and in the included moraines and till at a depth of 1 or 2 feet. Surface features indicative of permafrost are not common and are primarily stone circles and stone nets.

One area of thermokarst (unit 10) covering about 2 square miles is in the southwestern part of Valdemar Glückstadt Land near Hagen Fjord. It is located on stony silty sand outwash between morainal ridges and lies at an elevation of about 200 feet. The surface of the thermokarst consists of a number of interlocking irregular depressions up to 300 feet on a side and about 5 to 15 deep (fig. 16). A lake occupies a large depression in the center of the thermokarst and two small streams cross the area in valleys 30 to 50 feet deep. Irregular bodies of ground ice are within a few feet of the surface beneath the thermokarst.

Exposures of bedrock (unit 11) are not common nor extensive in Valdemar Glückstadt Land. In the northwest part of the area several low cliffs facing south and west are formed of Cambrian limestone. The cliffs are up to 120 feet high and have long talus-covered slopes at their bases. Just south of Kap Rigsdagen, cliffs of Pennsylvanian-Permian sandstone up to 200 feet high lie along Danmark Fjord. South

of Kap Kronberg on Danmark Fjord the limestone cliffs are from 400 to 600 feet high. Stretches of bedrock canyons and more open bedrock valleys, up to 10 miles long, occur along major streams and subordinate channels in the southeast part of the area. The canyons and valleys are 80 to 100 feet deep and are cut into Cambrian limestone.

Cliffs up to 120 feet high below which are long, steep bedrock and talus slopes occur along the peripheries of the plateaus in the southwestern part of Valdemar Glückstadt Land.

Talus slopes and lateral moraines are extensive along the bluffs facing Danmark Fjord (unit 12). The bluffs are up to 200 feet high and the moraine and talus slopes are 30° to 40°. The deposits of the bluffs vary from large rock piles to slopes of sandy silt with numerous boulders and cobbles. Earth slumps, up to a few hundred feet long, occur in a few scattered areas along the bluffs, and generally extend to the top of the bluff, with a large hummocky pile of debris at the base. Isolated masses of ground ice are present in the moraines and talus.

Mylius Erichsen Land

The tableland aspects of the northern Greenland plateaus are well displayed in Mylius Ericksen Land (plate 5). The plateau upland in this area is 2,400 to about 4,000 feet above sea level; relief is 1,400 to 3,000 feet. The higher portions of the plateau, generally above 3,000 feet, are covered by small ice caps from 100 to about 500 feet thick. The plateau is dissected into a series of mesa-like blocks by broad, flat-floored, glaciated valleys. The valleys are up to 2 miles wide and from 1,000 to 2,800 feet below the adjacent upland. The mesa-like plateau remnants are up to 40 miles on a side and are bound by steep slopes and cliffs. Drainage is by large, braided streams flowing along the major valleys. Tributaries are short and small, generally flowing down the front of the plateau blocks at right angles to the major streams. Ground ice in the form of continuous, thick beds is present at a depth of 2 to 8 feet in the valleys and elsewhere as lenses and thin beds at a depth of 2 feet or less. The area is barren of vegetation except for isolated plants. Mylius Erichsen Land has been glaciated at least twice. The older glaciation was primarily from huge ice tongues flowing down the large, interconnecting valleys, fed in part from the Greenland Ice Sheet and from local ice caps. In this older glaciation the valley glaciers overlapped onto the fringes of the adjacent plateaus in many areas. The later glaciation (Würm-Wisconsin) consisted primarily of valley glaciers that overlapped the plateau only in the lower reaches of Zig-Zag Dal and Hjertefjeldsdalen.

Alluvial valleys and deltas (unit 1) are extensive in this area. The valley floors are flat and are cut by numerous braided stream channels. The channels are up to 200 feet wide and from 2 to 6 feet deep. The deltas have uniform surfaces and slope from 1° to 15°. Both

the alluvial valleys and deltas are formed of sand with some scattered areas of cobbles. Ground ice is present but is at a depth of 6 to 8 feet. Small segments of river terraces (1a), as much as 200 feet above the alluvial floors, are along the large valleys. They are formed of subrounded cobbles in a matrix of silty sand. Sand flats (1b) are extensive on Sjaellandssletten (fig. 12) where they form gently domed plains adjacent to the alluvial valley. The center of the plains are up to 100 feet above the valley floors and have a rippled surface. The sand is well sorted and grain size is dominantly 0.3-1.0 mm. The sand is dry in the upper 6 inches and moist below. The sand deposits are 3 to 8 feet thick and rest on clay-silt deposits (Davies and Krinsley, 1961).

Marine plains and terraces (unit 2) are along Danmark Fjord at the mouths of Zig-Zag Dal and Hjertefjeldsdalen. The plains extend from sea level to over 300 feet and are cut into two major benches with surfaces at 40 to 160 feet. The plains and terraces are mainly clayey silt and fine sand with scattered cobbles and boulders. Much of the surface of the plains is cut by numerous arcuate, shallow valleys up to 20 feet deep and about 100 feet wide. The valleys are spaced from 300 to 600 feet. Somewhat similar, but more highly dissected plains (unit 3) formed of clayey silt, lie along the river in the upper part of Sjaellandssletten.

Morainal ridges (unit 4) are on the flanks of all the major valleys. They are convex downstream, forming a series of successive frontal moraines. They are composed of stony clay silt and are from 20 to 300 feet high. The tops are rounded to flat and the sides of the moraines slope from 10° to vertical. On the south side of Sjaellandssletten is an area of kame terraces (4a) 6 miles long and up to 3 miles in width. The terrace surface is flat, 30 to 100 feet above the rest of the valley, and encloses two large lakes. The front of the terrace is an undulating slope at 10° to 30°. The kame terraces are composed of subrounded pebbles and cobbles in a matrix of fine sand forming a veneer up to 8 feet thick over sandy, silty clay.

Older ridge moraines in the upper part of Zig-Zag Dal have been modified greatly by overriding of ice and outwash (unit 5). They have been reduced to undulating and rolling flats with smooth surfaces. Composition is similar to the ridge moraines. Ground ice is present at a depth of 2 feet or less in all moraines. Rectangular polygons, up to 500 feet on a side, with depressions up to 3 feet deep along their edges, cover most of the moraines.

The upland of the plateaus contains a thin cover of till (unit 8) composed of scattered pebbles and cobbles in a matrix of sandy silt. Small rock outcrops (unit 11) protrude through the till over all the upland, and bare rock slopes and cliffs are continuous along most of the plateau fronts. The rocks are dominantly sandstone of the Hagen

Fjord Group (uppermost Precambrian). Upper Precambrian orthoquartzite occurs in the upper part of Zig-Zag Dal. The rocks are not folded although they dip gently to the northeast (Haller, 1970). Because of their close association the till and bedrock have been grouped together in this study to avoid cartographic clutter.

Small areas of channelled uplands (unit 9) occur throughout the area on the edges of the plateaus where glaciers lapped over from the valleys (fig. 21). About 10 areas are extensive enough to be shown as separate entities. In these the channels are up to 200 feet deep, and 400 feet wide. The channels are subparallel and arcuate in plan. They are spaced from 100 to 600 feet and are separated by morainal or bedrock ridges.

The flanks of Femte-Maj Dal and a few other localities along major valleys are covered by alluvial fans (unit 12). The fans occur at the base of steep slopes where narrow, parallel valleys debouch. The valleys are spaced 500 to 1,000 feet and the fan deposits at their base form a series of coalesced deltas sloping from 15° to 35°. The fans are composed of boulders and angular cobbles in a matrix of coarse-grained sand and pebbles.

Skjoldungelv Area, Kronprins Christian Land

At the head of Danmark Fjord a large lowland connects the fjord and the Greenland Ice Sheet (plage 6). The ice sheet contains a large reentrant where the trend of the ice front changes from a western to a northern trend. Two large river systems, among the largest in Greenland, drain the meltwater from the ice sheet to Danmark Fjord. The entire area was covered by the expanded ice sheet and coalesced ice caps during the Würm-Wisconsin glaciation; evidence of former glaciations is not discernible. Discharge of meltwater and outwash as the ice sheet retreated at the end of the glaciation was so great that much of the fairly recent moraine along the Skjoldungelv has been greatly modified. Bedrock is sandstone and some dolomite of the Hagen Fjord Group of uppermost Precambrian age underlain unconformably by late Precambiran orthoquartzite. All these rocks dip gently towards the northeast (Haller, 1970).

The Skjoldungelv and its tributary heading in Campanuladal are braided streams 2 miles or more in width (unit 1). The braided channels are numerous, each up to 500 feet wide and 2 to 4 feet deep (fig. 22). The river banks are steep, abutting bedrock and morainal hills, and they rise to heights of 50 to over 200 feet. The river bed is dominantly fine sand and silt with pockets and lenses of poorly graded pebbles and cobbles.

River terraces (1a) are confined to short segments of the two major streams. They are 40 to 120 feet above the river and are

generally raised deltas at the mouths of subordinate tributaries. The surface of the terraces are dissected and their fronts are irregular. They are composed of poorly sorted gravel in a silty sand matrix.

Sand flats (1c) are extensive in the middle part of the Skjoldungelv and near the mouth of the stream flowing from the head of Campanuladal. The flats rise gently and the centers are 10 to 40 feet above the adjacent river channels. The deposits on the flats are fine-grained sand and the surface is covered by low dunes, sand ripples and wind scallops.

Morainal ridges (unit 4) cover about half of the ice-free land in the area. Most of the ridges are relatively young and little modified. They stand from 20 to over 300 feet high and have side slopes of 15° to 35°. They are formed of sandy clay with numerous cobbles and boulders. Ground ice is present a foot or two below the surface and much of the ground is covered with depressed-edge polygons up to 500 feet on a side. Outwash has modified, by rounding, some of the moraines in the section along the east side of the study area and adjacent to the ice cap in the lake region at the head of Campanuladal.

There are large areas of modified morainal ridges (unit 5) along the east side of Skjoldungelv and adjacent to the front of the ice sheet east of Kap Georg Cohn. As in previously described areas, these moraines have been smoothed, rounded, eroded, and their relief greatly reduced by outwash deposited in the valleys between the ridges. Some areas of modified morainal ridges have been so highly dissected (5a) that their continuity has been almost obliterated and they now are broken and isolated remnants of once continuous ridges.

Till-covered uplands (unit 8) and channelled uplands (unit 9) are in the hilly area in the central part of the ice-free land area. The till is a thin layer of stony silty sand about a foot or two thick over bedrock. Outcrops of bedrock are small but numerous in the upland till. Channels in the channelled uplands are bordered by the upland till. They are shallow, arcuate, parallel channels up to 50 feet deep and 100 feet wide with steeply sloping walls. The channels are spaced from 1,000 to 3,000 feet apart and cut into bedrock.

Bedrock outcrops (unit 11) are most extensive along the side of Skjoldungelv where sandstone and some dolomite occur. Elsewhere small, widely separated outcrops of these rocks protrude through the till and ridge moraines along steep slopes and in narrow valleys. West of Campanuladal and in the vicinity of Kap Georg Cohn similar small, isolated outcrops of upper Precambrian orthoquartzite are common in the area of morainal ridges.

The front of the Greenland Ice Sheet is mainly a cliff from 40 to over 150 feet high along half of its length in this area (fig. 23). Behind the cliff is a steeply rising slope that grades into the gently undulating surface of the inner part of the ice sheet. Meltwater streams have cut closely spaced, narrow channels into the slope zone; many of these channels have cut deep into the face of the ice cliff and grade into valleys in the ice-free areas. The ramps are gentle convex slopes ranging from 5° to 30° that grade from the ice sheet to the land. They are up to 10 miles in width and the slopes extend back onto the ice for up to a mile and cover a rise of 50 to 400 feet. Steep ramps have slopes of 30° to 60°. The ramps are furrowed by shallow meltwater channels up to 10 feet deep and 5 to 10 feet wide, spaced 5 to over 200 feet apart.

Herlufsholm Strand

Herlufsholm Strand is a portion of the extensive area of marine plains that border the Arctic coast of northern Greenland (plate 7). It is a wave-cut platform that bevels folded rocks and, in the area of Herlufsholm Strand, coincides with the surface on which Late Paleozoic-Mesozoic sediments were deposited. During two glaciations, ice-tongues extended from Independence Fjord onto the strand but in the last glaciation only piedmont glaciers, formed by coalesced valley glaciers, covered the inner part of the strand. Submergence and consequent wave action greatly modified the old morainal ridges in the coastal area. Ground ice is present 6 to 12 inches below the surface on the strand and for practical purposes, there is no active zone above the permafrost. The strand is barren of vegetation except for single isolated plants.

Alluviation (unit 1) is confined to a few deltas of large streams which contain poorly sorted deposits of silty sand and gravel. Most of the lower part of the strand is formed of marine-planed terraces (2a) and high strand ridges (2b). The terraces extend to an altitude of 30 feet and merge without distinct fronts. The terraces have gently sloping surfaces and are composed of angular cobble and pebble gravel in a matrix of coarse sand (Davies and Krinsley, 1961). The high strand ridges extend from 30 to about 90 feet above sea level (fig. 17). Eleven major strand lines, each consisting of coarse beach shingle in a ridge 2 to 5 feet high, occur in this interval of 60 feet. The slopes on the seaward sides of the ridges are 25° to 37° while the back slopes are up to 20°. Marine silt (2c) occurs in a small section in the southeast part of the area. It forms a highly eroded plain with a rough irregular surface near sea level. A series of islands and shoals lie offshore the northeast coast of Herlufsholm Strand (2d). These are old morainal ridges, now partially submerged, that have been smoothed into low, gently rounded offshore terraces and stand from a foot to 30 feet above sea level. They are composed of poorly sorted gravel in a matrix of sandy and silty clay.

On the inner edge of the strand is a zone of morainal, northwest-trending ridges (unit 4). These ridges are 10 to over 100 feet high with smooth, rounded summits and extend from a few hundred feet to 3 miles in length. They are composed of cobbles and boulders in gray sandy and silty clay with a pavement of closely packed angular cobbles. There are two areas adjacent to the morainal ridges where these have been smoothed and filled by marine action (unit 5). This modification has been limited and the relief, surface configuration, and continuity are more characteristic of moraine than terraces. The plateau upland bordering the strand on the southwest is composed of late Paleozoic and Mesozoic sandstone which crops out in low, discontinuous ledges along the flanks of the plateau. The upland is covered by a veneer of old till (unit 8) up to 2 feet thick. The till is composed of angular cobbles and boulders from which most of the finer material has been removed. Extensive areas of outcrop of the Paleozoic-Mesozoic sandstones (unit 11) are in the northwestern part of the area on the lower flanks of the plateau. The bedrock is cut into low rounded hills with relief up to 300 feet separated by open valleys with walls sloping up to 45°.

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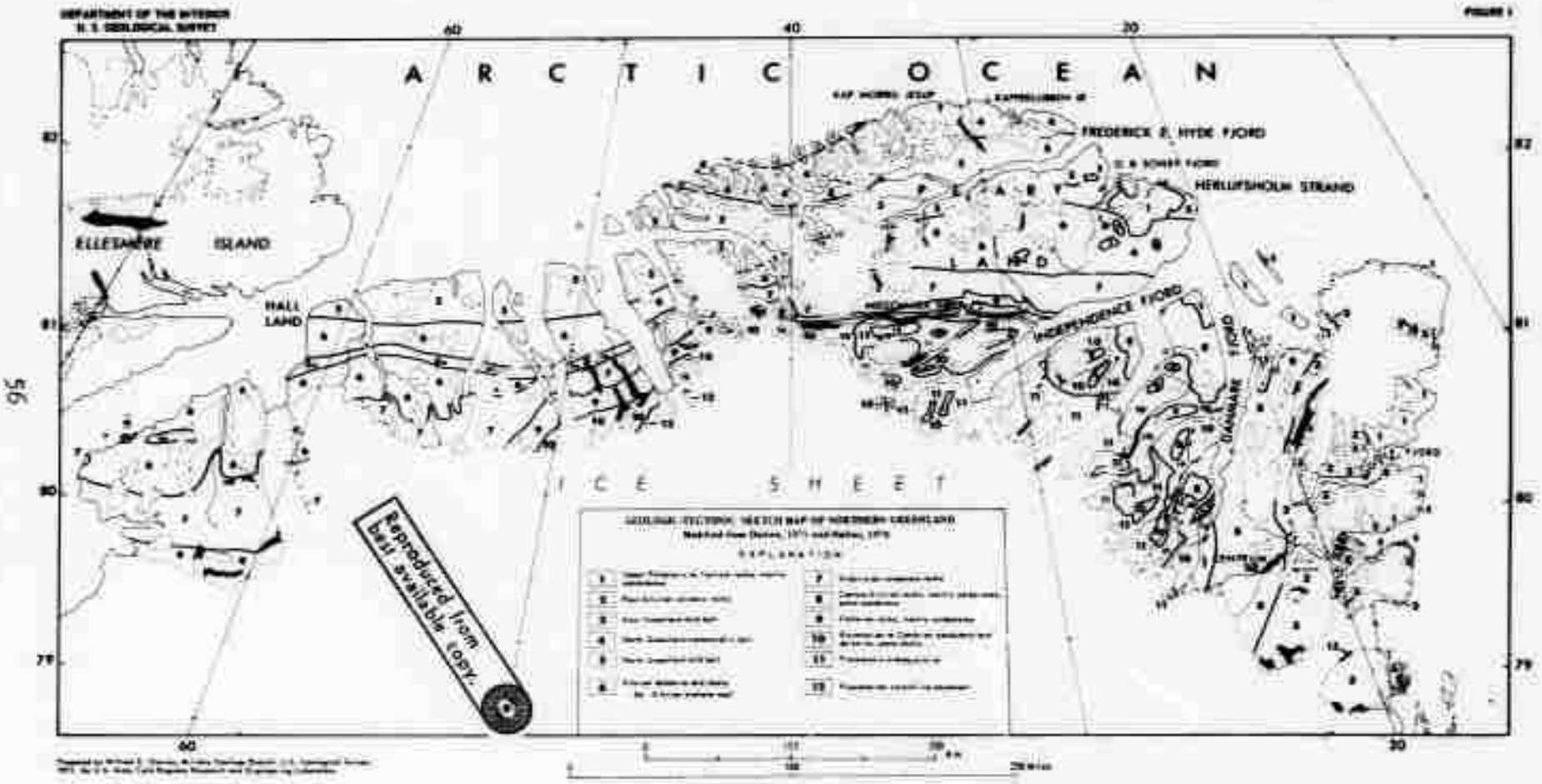
ARCTIC OCEAN
ELLESMERE ISLAND
HALL LAND
FREDERICK E. HYDE FJORD
HERLUFSHOLM STRAND
INDEPENDENCE FJORD
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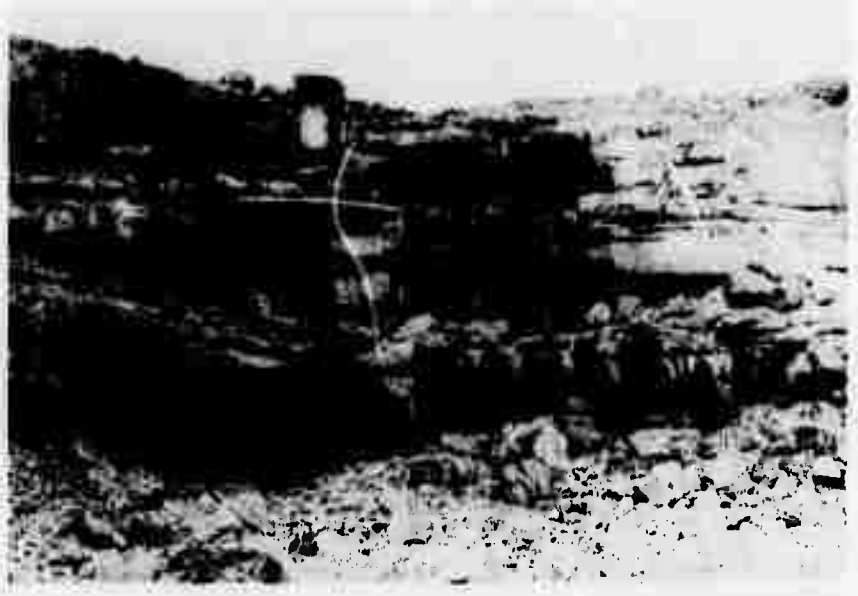
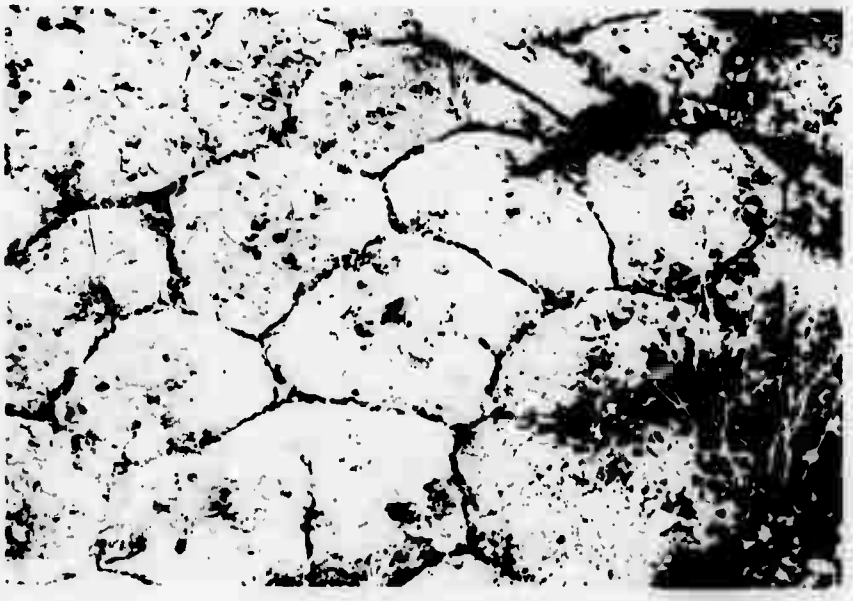


Figure 2. Silurian dolomite on the front of the reef bioherm, southwestern part of Polaris Forbjerg . photo by Davies 8/16/58

Figure 3. Folded Cambrian dolomite, Chester Bjerg, Polaris Forbjerg. photo by Davies 8/16/58

Figure 4. Quartzite and schist in the folded metamorphic belt of northern Greenland, east side of Dobbeltsø. photo by Davies 7/6/70

Figure 5. Plateau with concordant upland on Ordovician carbonate rocks, view northeast, west end of Midsommer Søer. photo by Davies 7/10/60



6. Desiccation polygons in clayey silt, Pileheden, Polaris Forbjerg.
   photo by Air Force Terrestrial Science Laboratories 1959

7. Wyckoff Fjeld, view south from strand flat at Peary's cairn, Kap Wyckoff. photo by Davies 7/5/60

8. View south on Polaris Plain from Graasten Elv towards the Monument. photo by Davies 8/10/58

9. Hauge Fjeld, view east from plain on west side of Graasten Elv. photo by Davies 8/13/58

10. Stepped plateau formed of Silurian sandstone, northern Peary Land. photo by Davies 7/7/60

11. Terminal moraine ridges, 25 miles west of Mudder Bugt view west; ridges are up to 600 feet high. photo by Davies 7/4/60

12. Sjaellandsslette, view west up Zig-Zag Dal.
photo by Davies 7/2/60

13. Plateau upland, west of Centrum Sø, view east.
photo by Davies 8/15/60

14. Prinsesse Caroline Mathilde Alps, view east from head of Ingolf Fjord. photo by Davies 6/28/60

15. Foreset delta beds overlain by beach gravel, delta terrace on east side of Danmark Fjord. photo by Davies 6/26/60

16. Thermokarst in southwest part of Valdemar Gluckstadt Land. photo by Davies 8/31/53

17. Raised strand lines, Herlufsholm Strand, view southwest at Kolnaes. photo by Davies 7/5/60

18. Badlands, clay-silt valley fill at south end of Vandredalen, view north. photo by Davies 7/2/60

19. Graastenelv, Polaris Forbjerg, view north at Teltbakken. photo by Davies 8/11/58

20. Shallow, depressed edge polygons on clay-silt soil on the plain, Polaris Forbjerg. photo by Davies 8/16/58

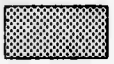
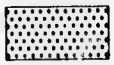
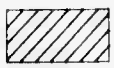
21. Channelled upland, southwest of Centrum Sø, typical of marginal channels cut into the plateaus of northern Greenland. photo by Davies 8/15/56

22. Skjoldungelv, view south at Fyn Sø.
photo by Davies 6/27/60

23. Front of ice sheet west of Kap Georg Cohn.
photo by Davies 6/27/60

DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

TERRAIN SUMMARY OF NORTHERN

MAP SYMBOL Plate 2 (4 sheets)	SUITABILITY FOR AIR CUSHION VEHICLES	LANDFORM	TERRAIN	RELIEF FEATURES					STREAM FREQUENC
			Relief	Slope %	Height Ft.	Spacing Ft.	Orientation	Width Ft.	No. per mile
	Suitable with 6 ft. skirt clearance	Alluvial valleys; flat undissected plateau; coastal flats	Low	<3	2-6 6-10 >10	50-200 2,000-10,000 None	Transverse Transverse	<10 10-100 100-1,000 >1,000	1.4 0.1 0.1 0.03
	Suitable with 10 ft. skirt clearance	Broad valleys with kames and cross-valley moraines; plains and plateaus covered by moraine and other glacial deposits; frost polygons common in areas covering up to 20 square miles	Moderate	2-10	2-6 6-10 10-20 20-30 30-50 >50	100-500 400-1,000 400-1,000 1,000-5,000 10,000 None	Random Random Random Random Random	<10 10-100 100-1,000 >1,000	1.6 0.16 0.03 None
	Suitable with 30 ft. skirt clearance	River terraces flanking broad valleys	Moderate	2-6 broken by scarps	<10 10-20 20-30 30-50 >50	None 400 1,000-5,000 400 500-1,000 400-500 1,000-5,000 1,000 20,000	Cross-valley Along valleys Cross-valley Along valleys Cross-valley Along valleys Cross-valley Along valleys	<10 10-100 100-1,000 >1,000	1.4 0.1 0.1 None
	Suitability fair with 30 ft. skirt clearance	Rounded hills with series of low scarps on all sides; hills rise 200 to 2,000 ft. above valleys	Moderate	20	10 10-20 20-30 >30	Uncommon 100-500 400-600 None	Random Random	<10 10-100 100-1,000 >1,000	2 0.5 0.05 None
	Suitability poor with 30 ft. skirt clearance	Rounded, conical morainal hills	Moderate to high	8-30	2-20 20-30 30-50 >50	Uncommon 100-200 500-1,000 2,000-5,000	Random Random Random	<10 10-100 100-1,000 >1,000	8 0.5 0.05 None
	Unsuited	Morainal ridges in broad valleys and on lowlands	High	30-100	2-20 20-30 30-50 >50	Uncommon 100-200 500-1,500 2,000-5,000	Random Random Random	<10 10-100 100-1,000 >1,000	1.4 0.1 0.1 0.1
	Unsuited	Alpine mountains; high dissected plateaus, highly dissected morainal hills and steep slopes bordering other terrain types	High	100 to vertical	2-50 >50	Uncommon 100 or less	Random	<10 10-100 100-1,000 >1,000	1.6 0.04 0.0 None

ORTHERN GREENLAND WITH REFERENCE TO OPERATION OF AIR CUSHION

(Table keyed to Terrain of Northern Greenland 1:500,000, 4 sheets, 1970)

STREAM FREQUENCY		VEGETATION	SOIL Symbols from Unified Soil Classification System	WINTER CONDITIONS	REMARKS
No. per mile	Max. depth Ft.				
1.4 0.1 0.1 0.03	0.5 2 4 10	Generally barren; sparse grass 6 inches high in scattered areas up to 1 mile square	Silty sand (SM) and silty gravel (GM) over 20 feet thick; locally in areas up to 10 miles long, inorganic silt, silty clay and rock flour over 20 feet thick	Snow 2 to 4 feet deep; drifts obliterate all relief	Valleys subject to floods in late May and June. Dusty in summer; local sandstorms
1.6 0.16 0.03 None	0.5 1 4	Grass up to 6 inches high in scattered areas of less than 1,000 feet square	Gravel-sand-clay mixtures (GC) 2 to over 50 feet thick	Snow drifts flatten slopes to 5% or less	Local flooding in valleys during late May and June
1.4 0.1 0.1 None	1 2 4	Small areas of grass up to 6 inches high	Poorly graded gravel and gravel-sand mixtures (GP) 5 to over 50 feet thick	Snow 2 to 5 feet deep; no modification of relief by drifts	Dry and dusty in summer; local sandstorms
2 0.5 0.05 None	0.5 2 2	Barren	Rubble consisting of boulders and poorly graded gravel (GP) less than one foot thick over limestone bedrock	Snow 2 to 8 feet deep; no modification of relief by drifts	
8 0.5 0.05 None	0.5 0.5	Grass and shrubs 6 inches high in scattered patches up to 100 feet square	Gravel-sand-clay mixtures (GC) 100 to over 500 feet thick	Snow 2 to 5 feet deep; does not modify relief	
1.4 0.1 0.1 0.1	1 2 4 4	Grass and shrubs up to 6 inches high in scattered patches up to 100 feet square	Gravel-sand-clay mixtures (GC) 50 to 200 feet thick, with interspersed areas of silty sand (SM) and silty gravel (GM) over 20 feet thick	Snow 2 to 5 feet deep; no modification of relief by drifts	Alluvial areas between moraines subject to floods in May and June
1.6 0.0 0.0 None		Barren	Rubble and poorly graded gravel (GP) generally less than one foot thick over bedrock; mainly limestone and sandstone except in northern Peary Land where metamorphic rocks are extensive	Snow 2 to 5 feet deep; drifts fill valleys in dissected moraines but do not modify relief elsewhere	

MAP SYMBOL	Co
O_1	
O_{1a}	
O_2	
O_3	
I_1	
I_2	
I_3	
I_4	
I_5	
I_6	
I_7	
Moving ice	

TABLE 1
Interagency Report
Military - 7

ER CONDITIONS | REMARKS

to 4 feet deep; drifts te all relief | Valleys subject to floods in late May and June. Dusty in summer; local sandstorms

ifts flatten slopes less | Local flooding in valleys during late May and June

te 5 feet deep; no mod- of relief by drifts | Dry and dusty in summer, local sandstorms

te 8 feet deep; no mod- of relief by drifts

e 5 feet deep; does fy relief

e 5 feet deep, no mod- of relief by drifts | Alluvial areas between moraines subject to floods in May and June

e 5 feet deep, drifts ys in dissected but do not modify ewhere

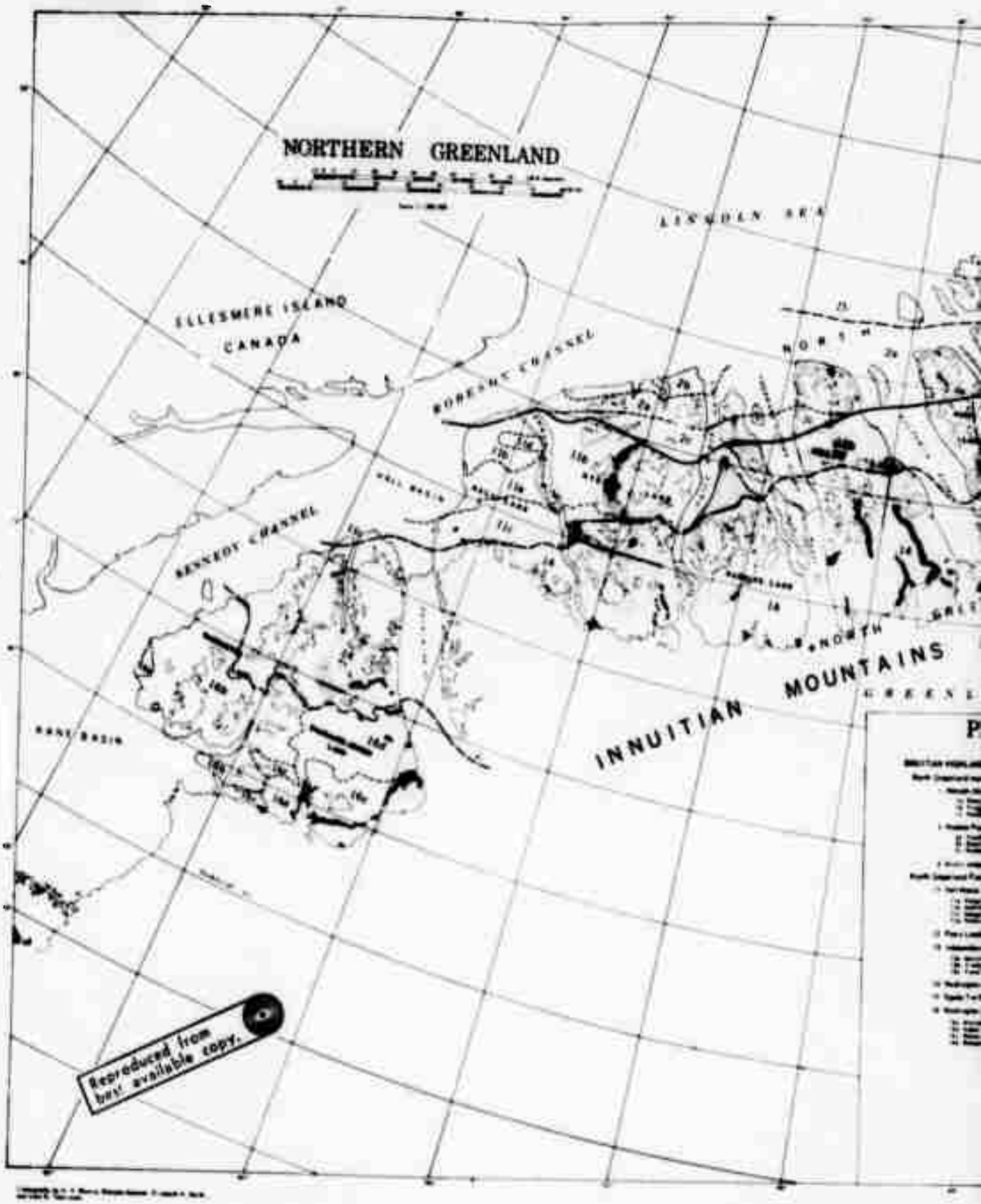
SHORE–ICE CONDITIONS

SUMMER
(Maximum melt late August)

MAP SYMBOL	Concentration of sea ice %	Puddling, spacing ft.	Puddling, size ft.	Coverage of icebergs %	Coverage of icebergs spacing	Ridge ice height ft.	Ridge ice spacing ft.
O_1	0	—	—	0	—	—	—
O_{1a}	1-5	—	—	0	—	—	—
O_2	0	—	—	1	1 mile	—	—
O_3	0	—	—	40	200 ft.	—	—
I_1	100	10-100	10-100 transverse	0	—	—	—
I_2	100	10-100	10-100 transverse	1	1 mile	—	—
I_3	100	10-100	10-100 transverse	40	200ft.	—	—
I_4	100	10-100	10-100 transverse	0	—	6	20-500
I_5	100	200-500	200-500 transverse	0	—	—	—
I_6	100	100-1,000	10-20 transverse	0	—	6-40	20-500
I_7	40	20-50	10-20 transverse	0	—	—	—
Moving ice	0-50	—	—	—	—	—	—

WINTER

Concentration of sea ice %	Coverage of icebergs %	Coverage of icebergs spacing	Ridge ice, height ft.	Ridge ice, spacing ft.	Smooth ice %
100	0	—	—	—	100
100	0	—	—	—	100
100	1	1 mile	—	—	100
100	40	200 ft.	—	—	100
100	0	—	—	—	100
100	1	1mile	—	—	100
100	40	200 ft.	—	—	100
100	0	—	6-40	20-500	50
100	0	—	—	—	100
100	0	—	60-40	20-500	10
100	0	—	—	—	100
60-100	—	—	—	—	60-100


DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY
NORTHERN GREENLAND
ELLESMERE ISLAND
CANADA
KENNEDY CHANNEL
KANE BASIN
INNUITIAN MOUNTAINS
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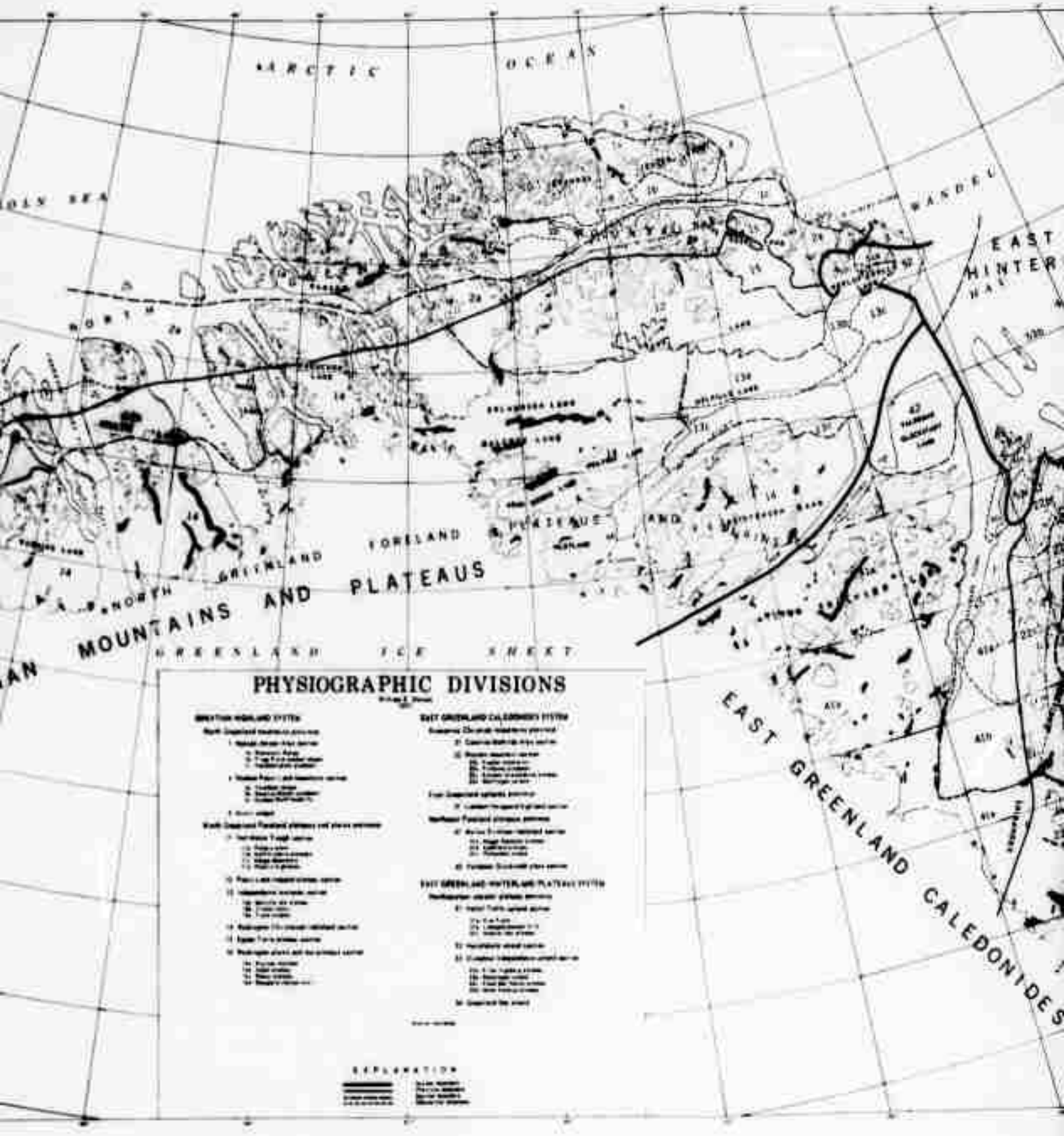
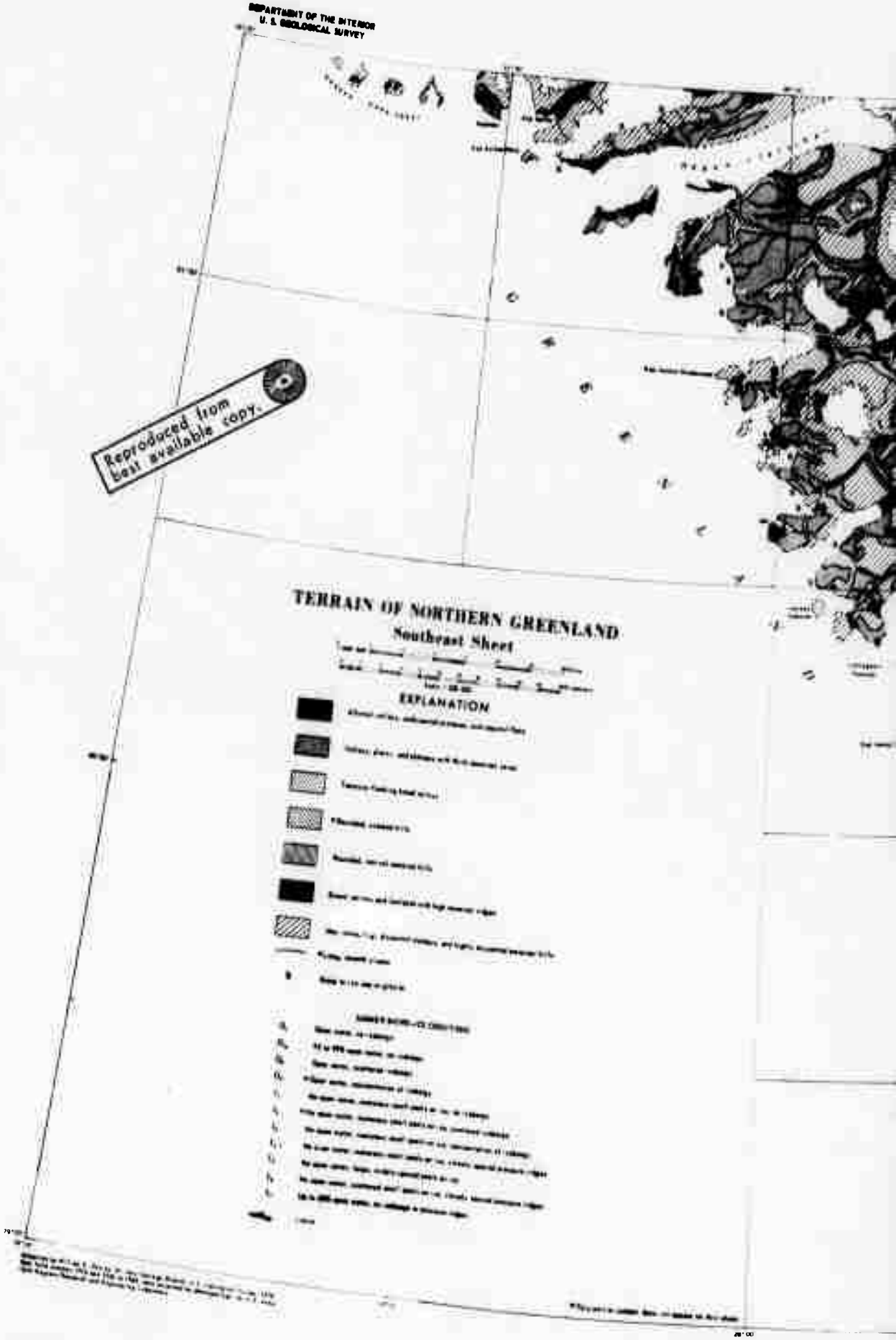

ARCTIC OCEAN
EAST GREENLAND CALEDONIDES
MOUNTAINS AND PLATEAUS
PHYSIOGRAPHIC DIVISIONS
EXPLANATION


OCEAN
EAST GREENLAND
HINTERLAND PLATEAUS
EAST GREENLAND CALEDONIDES
GREENLAND SEA
DIVISIONS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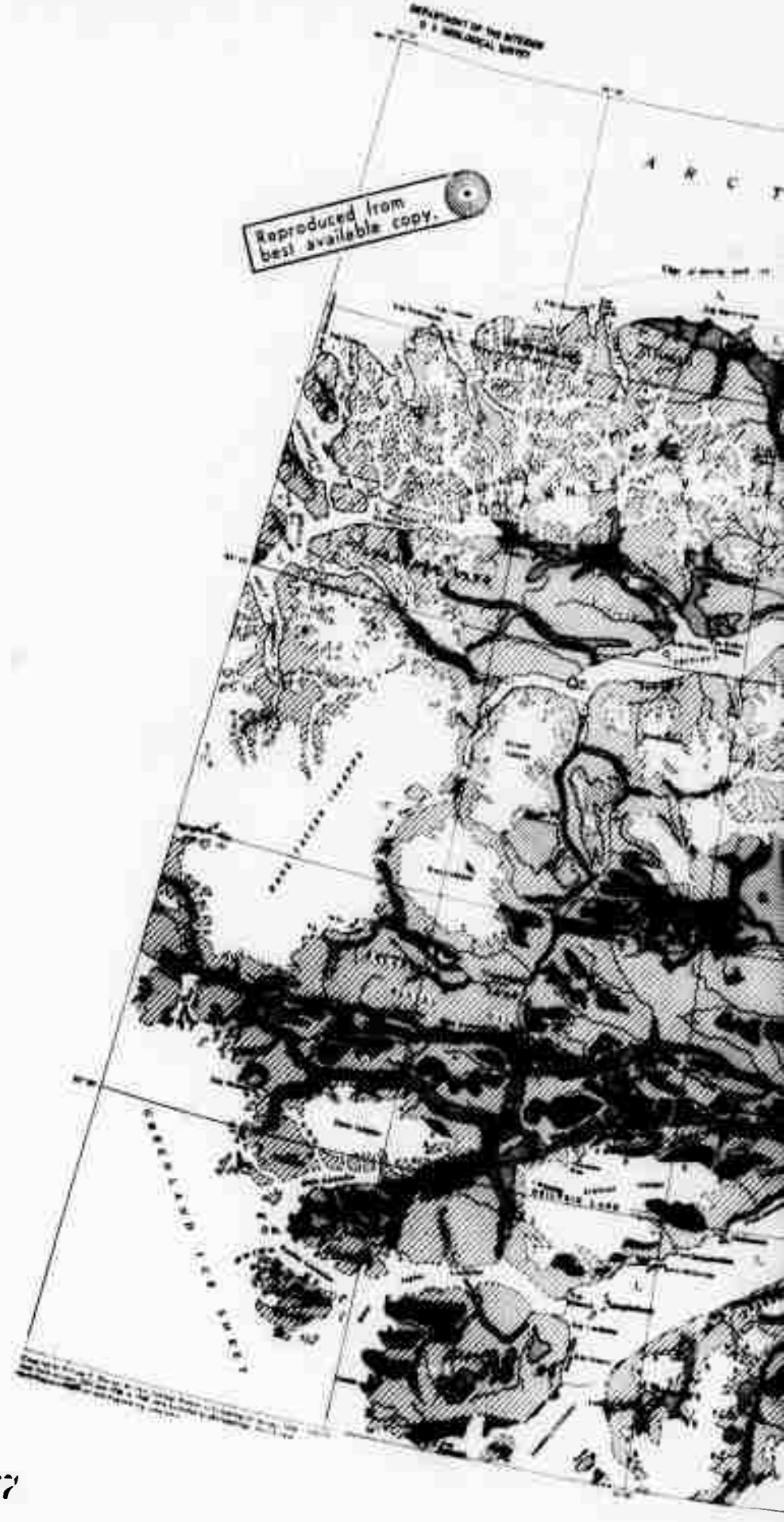
TERRAIN OF NORTHERN GREENLAND
Southeast Sheet
EXPLANATION


REENLAND


PLATE 2-5E
GREENLAND
SEA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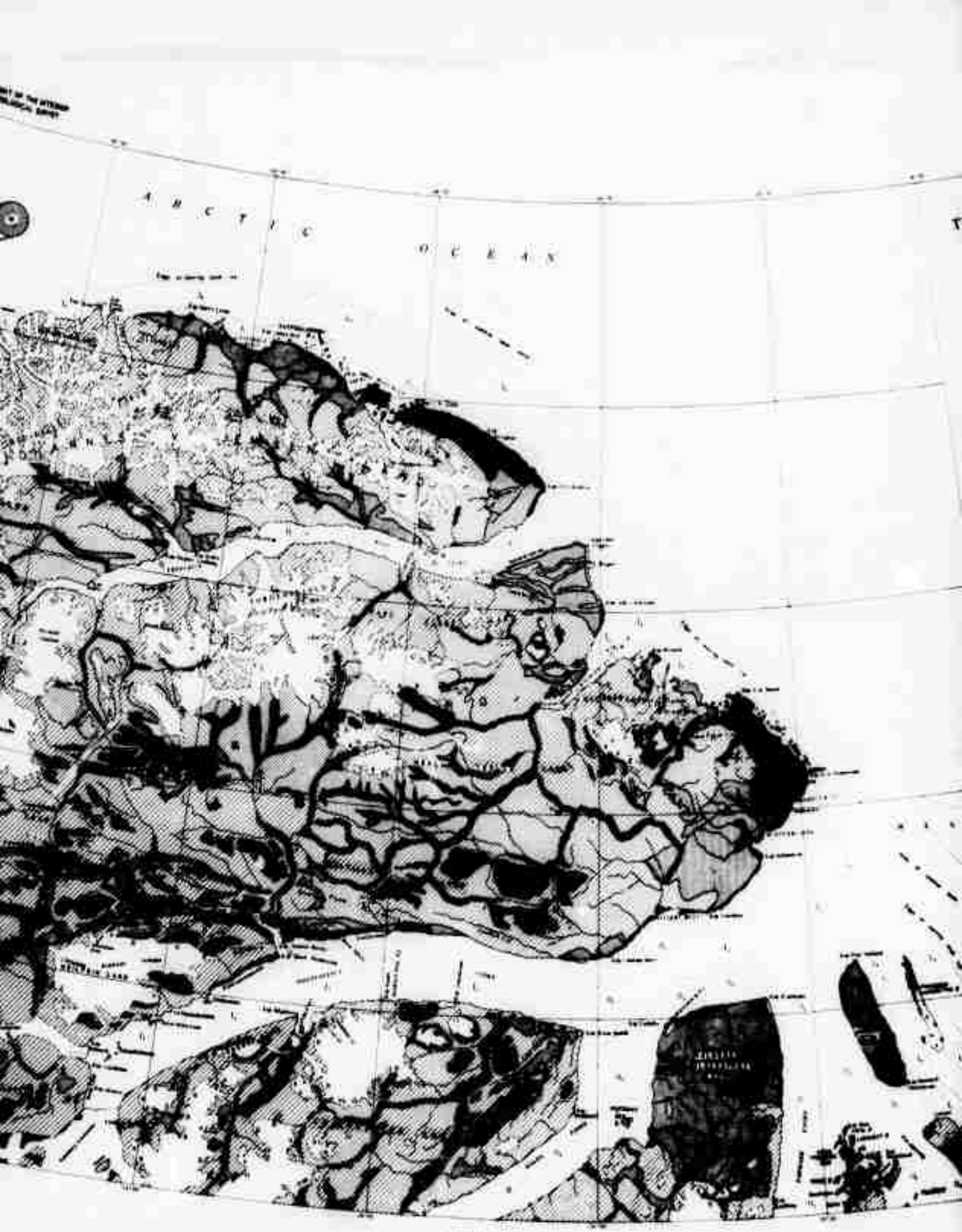
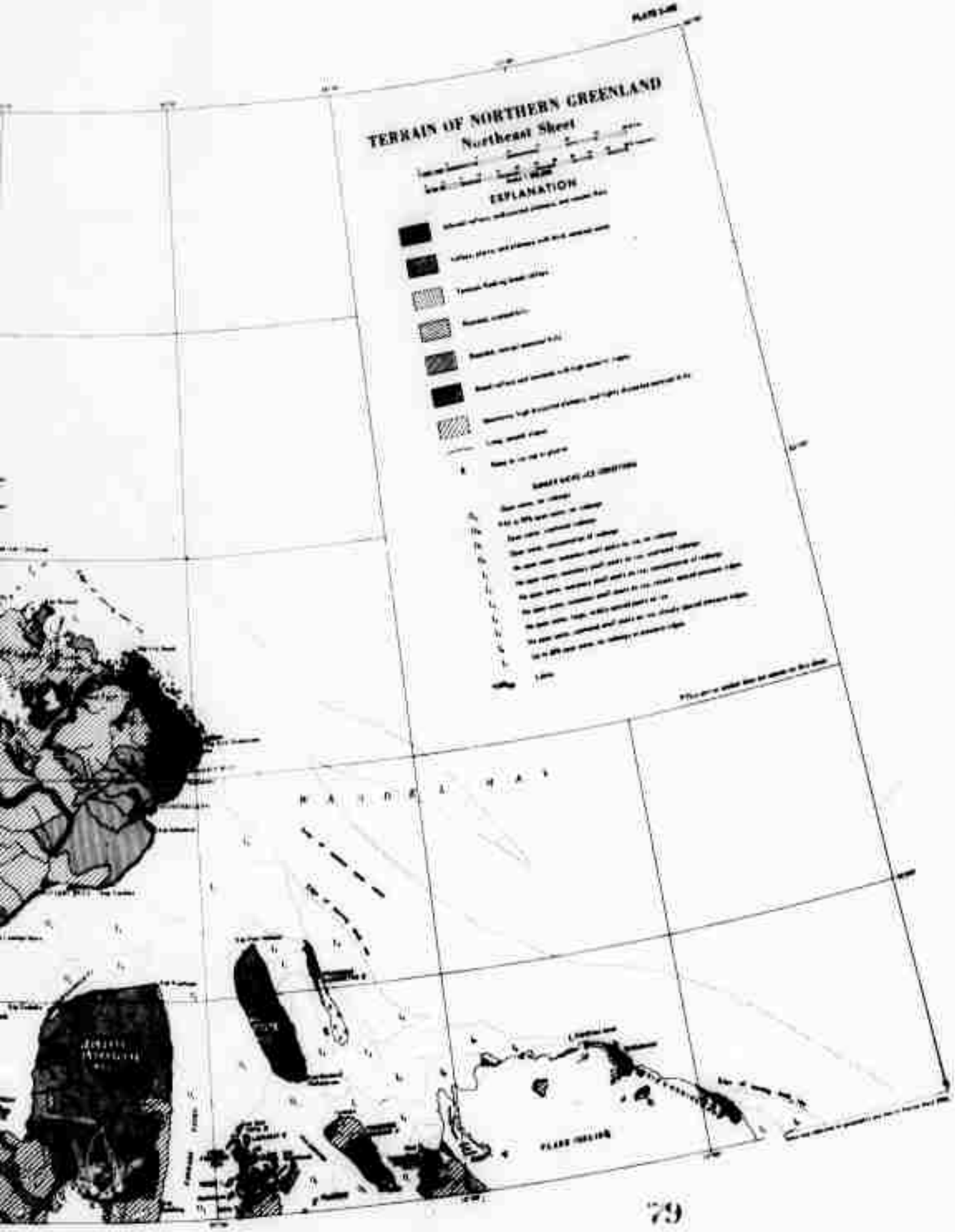

ARCTIC
OCEAN


TERRAIN OF NORTHERN GREENLAND
Northeast Sheet
EXPLANATION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ELLESMERE
ISLAND
CANADA
KANE
BASIN
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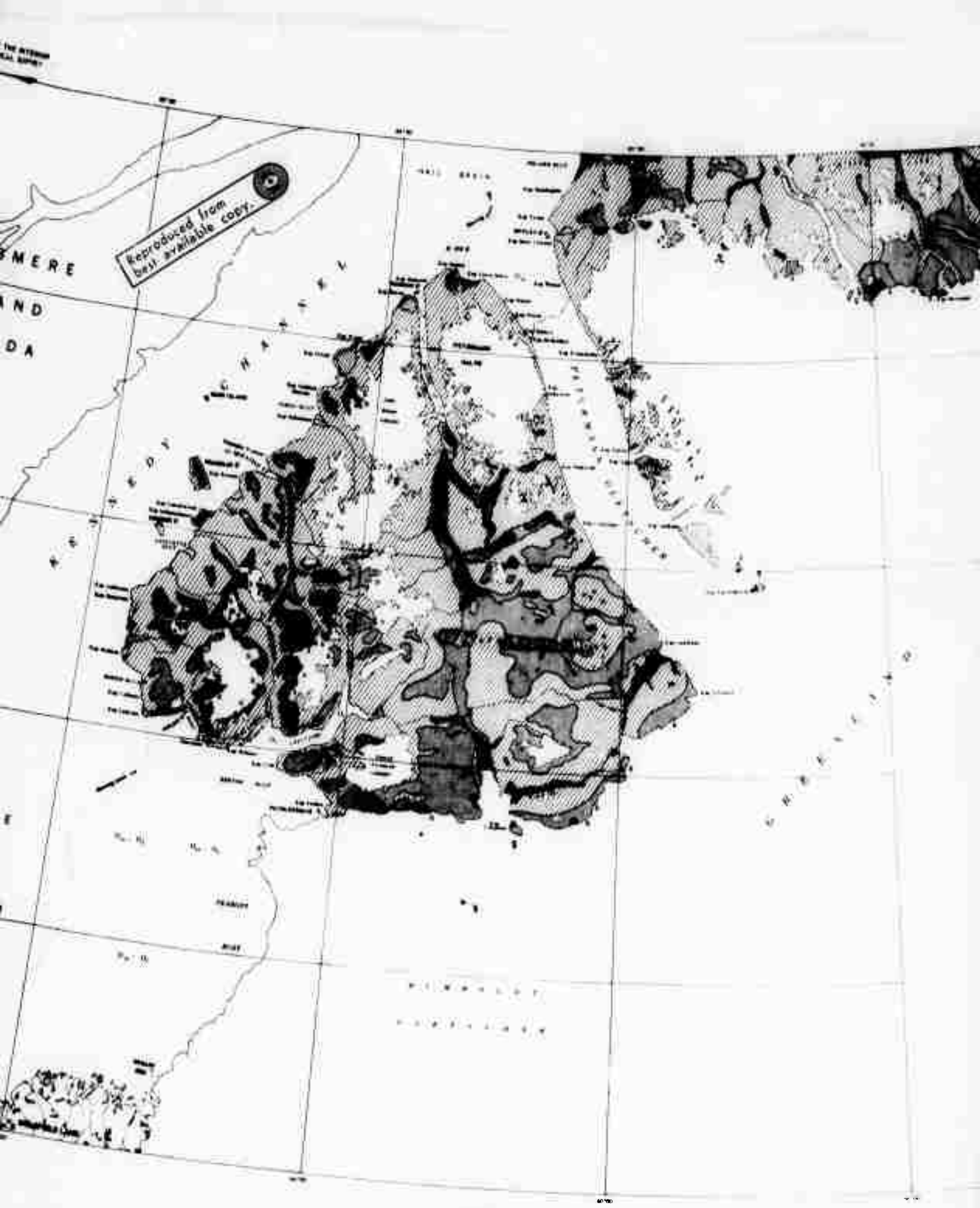
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TERRAIN OF NORTHERN GREENLAND
Southwest Sheet
Scale 1:500,000
EXPLANATION
Alluvial valleys, undissected plateaus, and coastal flats
Valleys, plains, and plateaus with thick morainal cover
Terraces flanking broad valleys
Rounded, scarped hills
* Rounded, conical morainal hills
Broad valleys and lowlands with high morainal ridges
Mountains, high dissected plateaus, and highly dissected morainal hills
* Long, smooth slopes
R Ramp to ice cap or glacier
SUMMER SHORE-ICE CONDITIONS
O1 Open water, no icebergs
O1a 95 to 99% open water, no icebergs
O2 Open water, scattered icebergs
O3 * Open water, concentration of icebergs
I1 * No open water, numerous small pools on ice, no icebergs
I2 * No open water, numerous small pools on ice, scattered icebergs
I3 * No open water, numerous small pools on ice, concentration of icebergs
I4 * No open water, numerous small pools on ice, closely spaced pressure ridges
I5 * No open water, large, widely spaced pools on ice
I6 * No open water, scattered small pools on ice, closely spaced pressure ridges
I7 * Up to 60% open water, no icebergs or pressure ridges
Lakes
* This unit or symbol does not appear on this sheet
Base map adjusted to geographic position of Station Nord 1955.
GREENLAND
SHEET 1


RTHERN GREENLAND
ent Sheet
ATION
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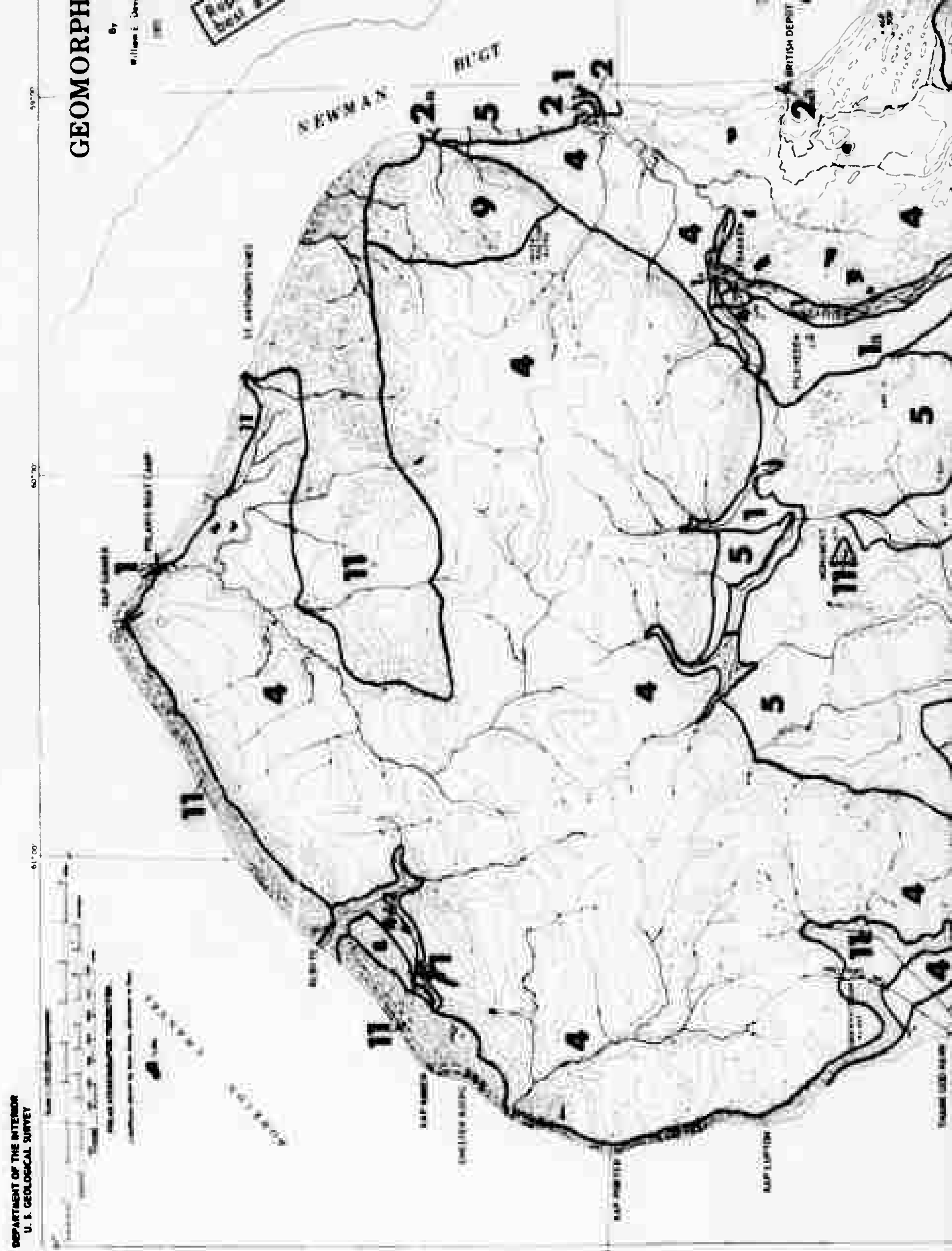
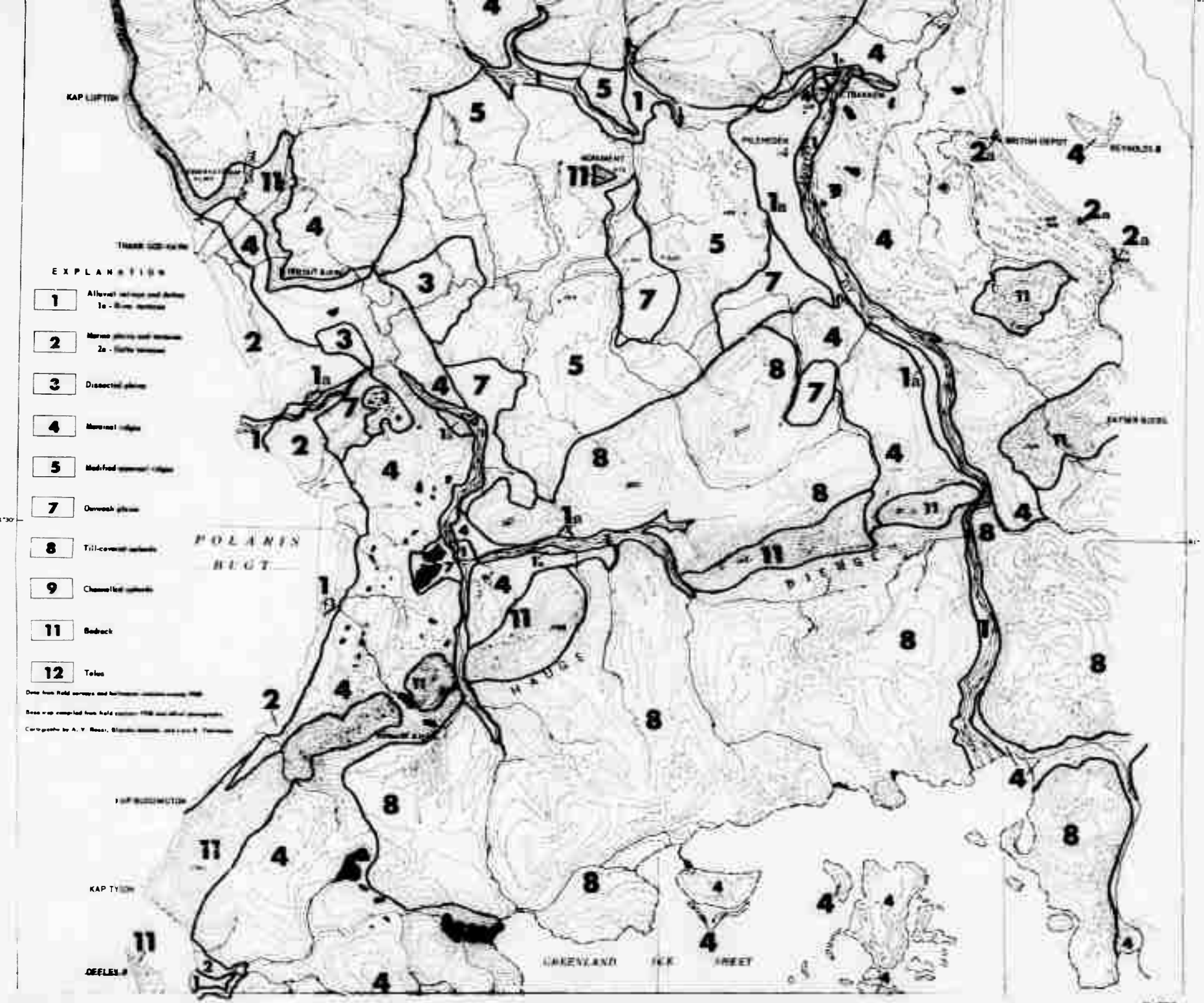
ARCTIC
OCEAN


PLATE
OCEAN
S-1
S-5

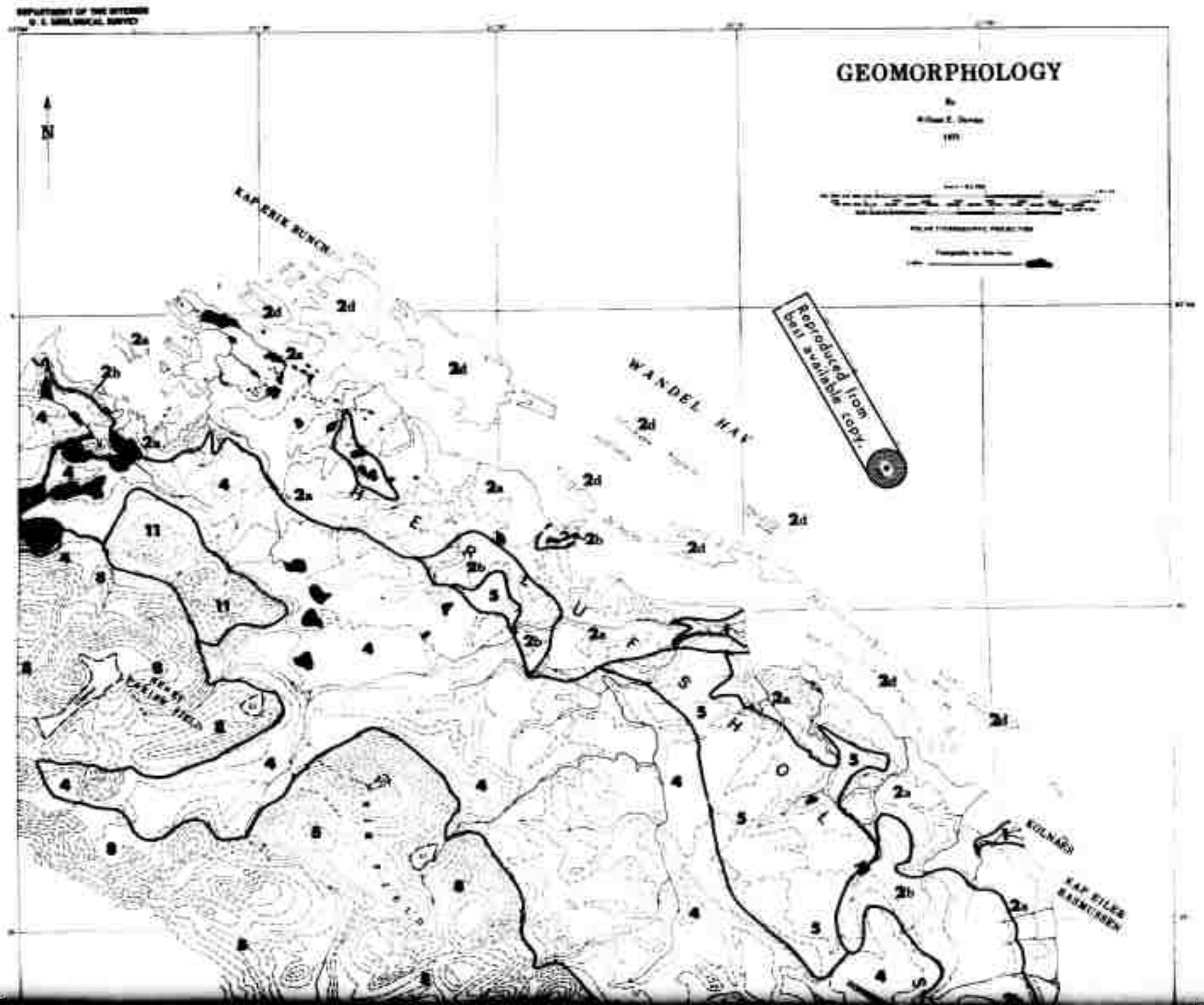

GEOMORPH
NEWMAN BUGT
BRITISH DEPOT
DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY



Prepared by William E. Davies, Military Geology Branch, [illegible] 1971, for U.S. Army Cold Regions Research and Engineering [illegible]

POLARIS FORBJERG NORTHERN GREENLAND

PLATE 3


GEOMORPHOLOGY
N
KAP ERIK BUNCH
WANDEL HAV
SHOAL
KULNARD
KAP ELKE RASMUSSEN
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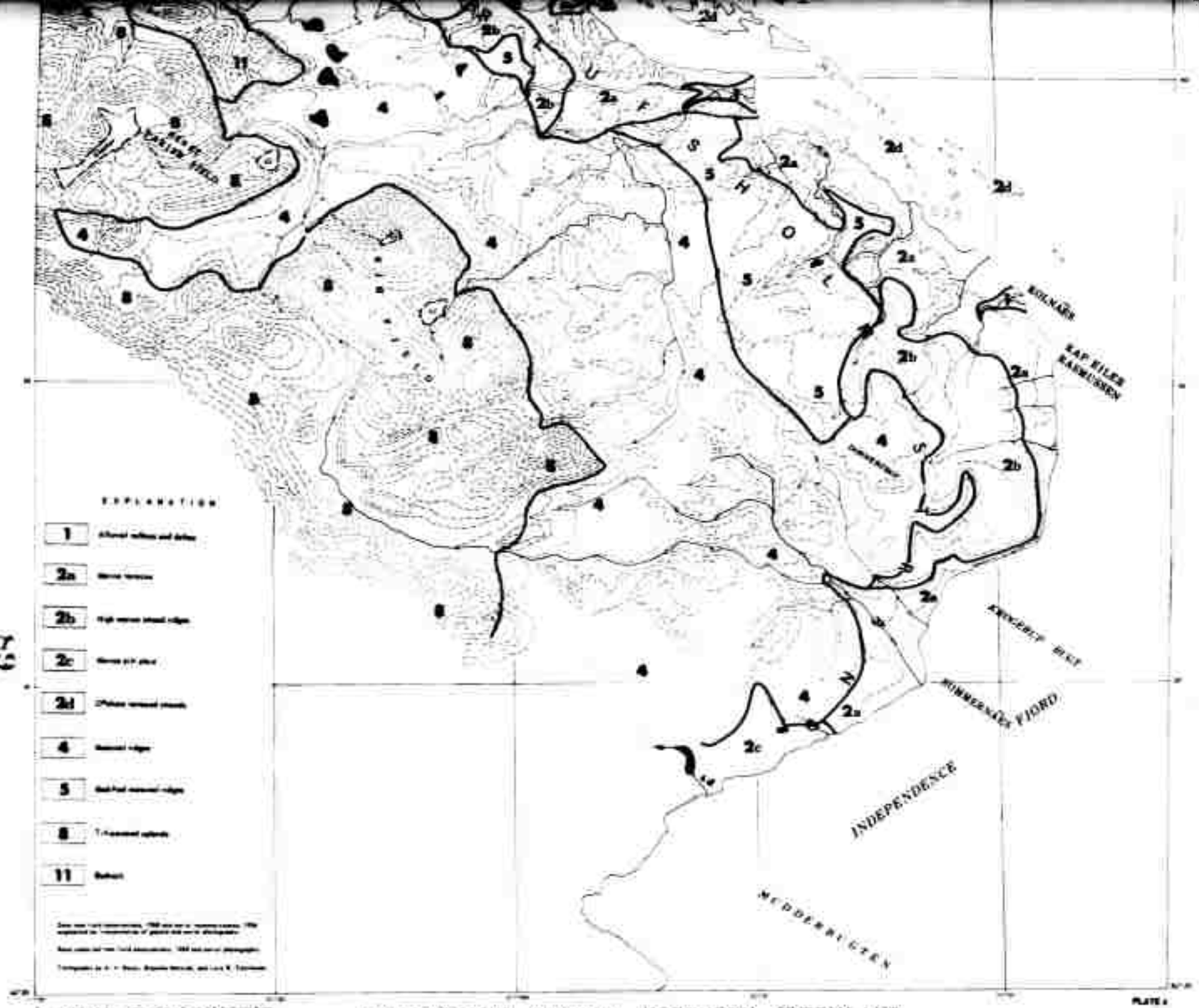
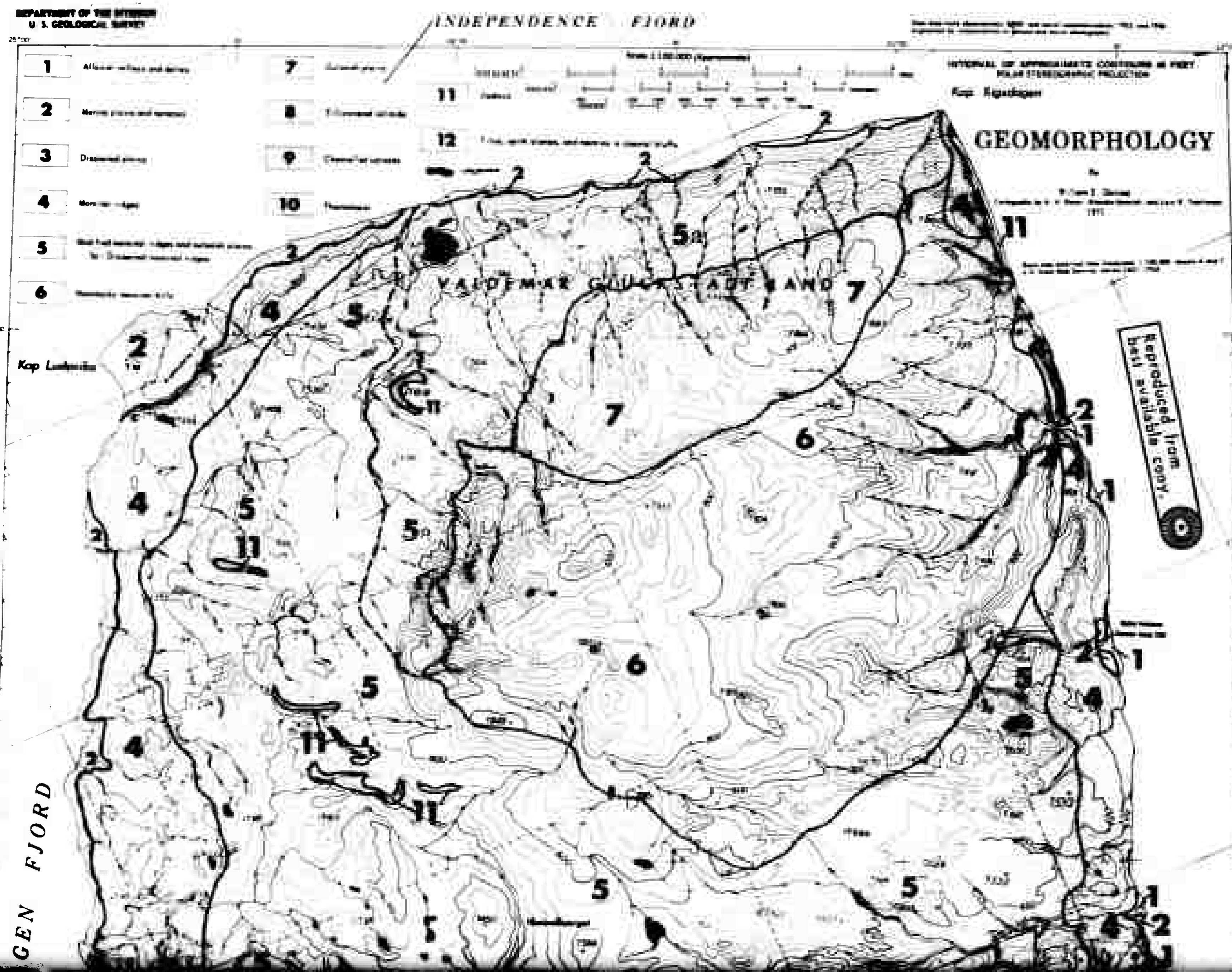


HERLUFSHOLM STRAND NORTHERN GREENLAND



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INDEPENDENCE FJORD
GEOMORPHOLOGY
VALDEMAR GLÜCKSTADT LAND
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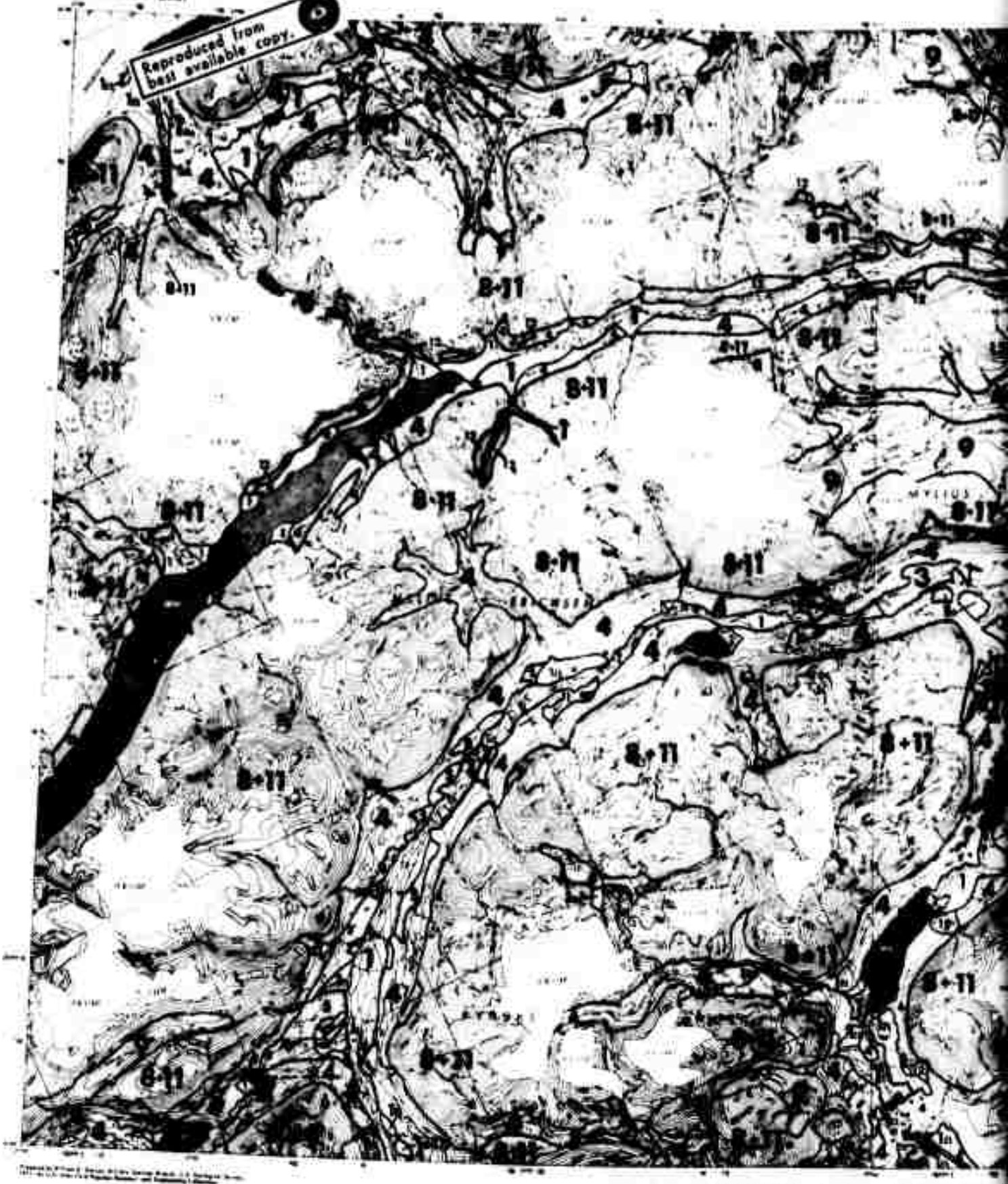
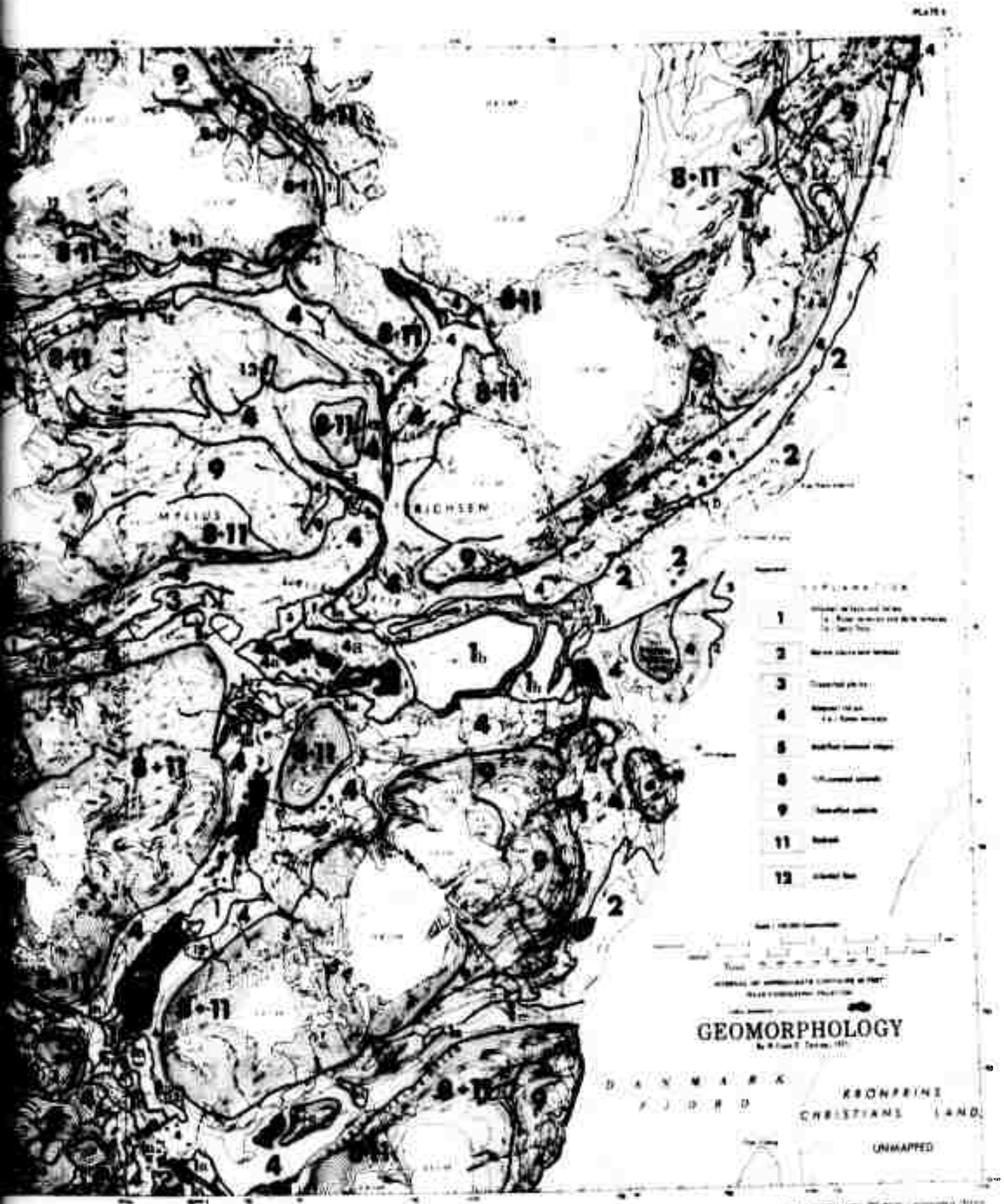
FJORD

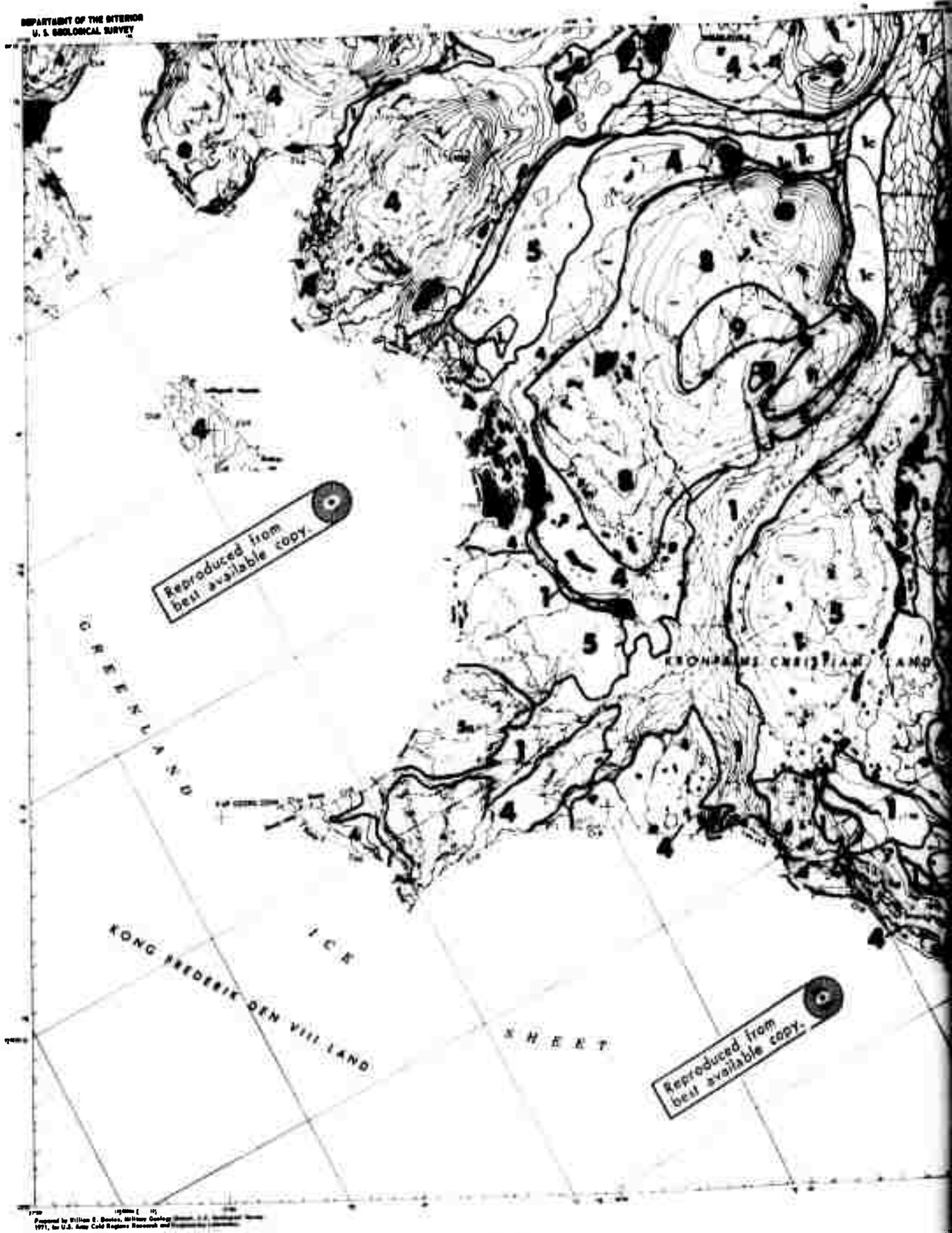
VALDEMAR GLÜCKSTADT LAND NORTHERN GREENLAND



MYLIUS ERICHSEN LAND NORTHERN



ISEN LAND NORTHERN GREENLAND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U. S. GEOLOGICAL SURVEY
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GREENLAND
KONG FREDERIK DEN VIII LAND
ICE
SHEET
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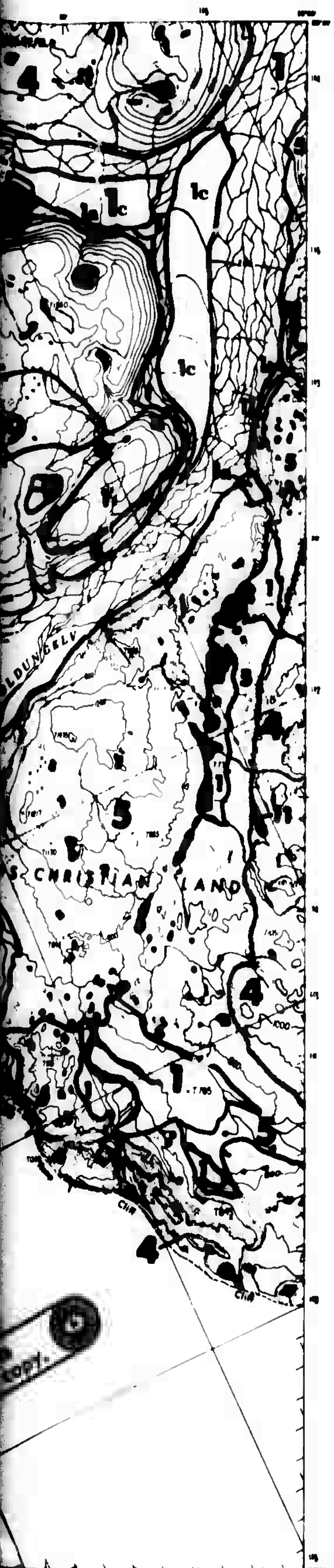

KRONPRINS CHRISTIAN LAND NORTHERN GREENLAND
SKJOLDUNGELV AREA

Scale 1:100,000 (Approximate)

INTERVAL OF APPROXIMATE CONTOURS 40 FEET

POLAR STEREOGRAPHIC PROJECTION

GEOMORPHOLOGY

By

William E. Davies

1971

EXPLANATION

- **1** Alluvial valleys and plains
  - 1a - River terraces
  - 1c - Sand flats
- **2** Marine plains and terraces*
- **3** Dissected plains*
- **4** Morainal ridges
- **5** Modified morainal ridges and outwash plains
  - 5a Dissected morainal ridges
- **6** Hummocky morainal hills*
- **7** Outwash plains*
- **8** Till-covered uplands
- **9** Channelled uplands
- **10** Thermokarst*
- **11** Bedrock
- **12** Talus*

* Unit does not occur on this sheet

Data from field observations, 19[illegible], [illegible] aerial reconnaissance, 19[illegible], [illegible] by [illegible] of ground and aerial photographs

Base map modified from Greenland 1:100,000, sheet [illegible]
U.S. Army Map [illegible] series C621 19[illegible]

Cartography by [illegible]